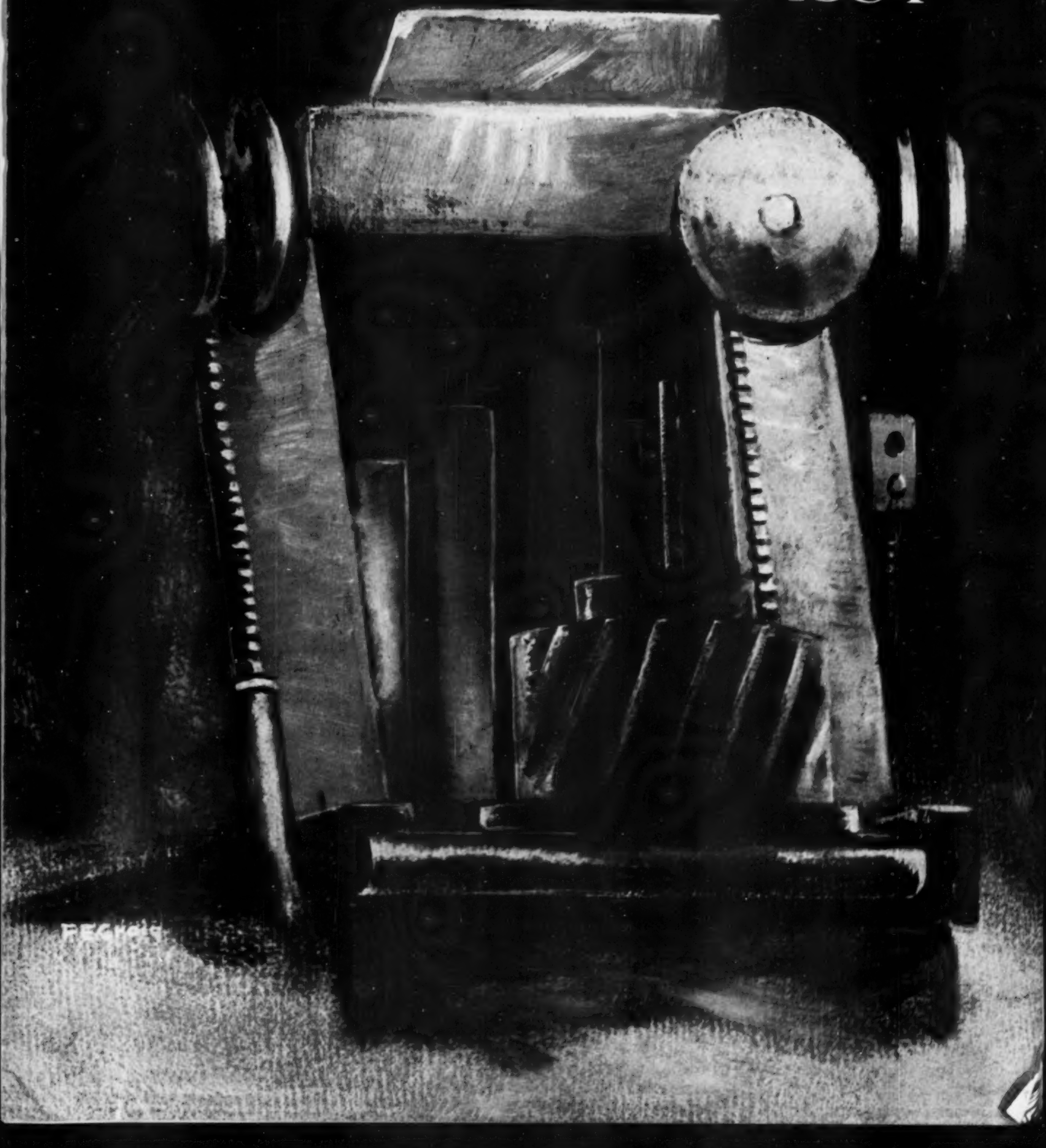
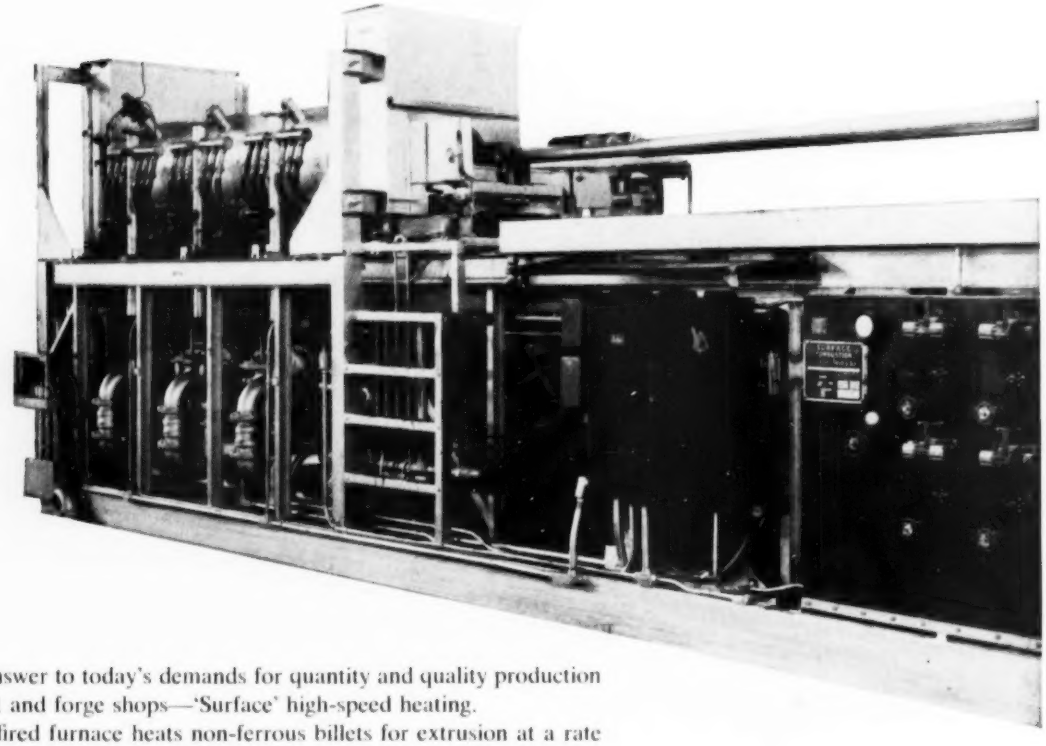
Metal Progress

November 1954





Metal Progress

November, 1954 **Vol. 66, No. 5**

Ernest E. Thum, *Editor*
Marjorie R. Hyslop, *Managing Editor*
John Parina, Jr., *Associate Editor*
Floyd E. Craig, *Art Director*

Cover by Floyd E. Craig

Table of Contents Continued on Page 3

Published monthly except bi-weekly in July, by American Society for Metals. Publication office, Mt. Morris, Ill. Editorial, executive and advertising offices, 7301 Euclid Ave., Cleveland 3, Ohio. Subscription $7.50 a year in U.S. and Canada; foreign $10.50. Single copies $1.50; special issues $3.00. . . . The American Society for Metals is not responsible for statements or opinions printed in this publication. . . . Requests for change in address should include *old* address of the subscriber; missing numbers due to "change of address" cannot be replaced. Claims for nondelivery must be made within 60 days of date of issue. No claims allowed for overseas subscribers. Entered as second-class matter at the Post Office in Mt. Morris, Ill.

Table of Contents Continued . . .

As I was saying...

I'M JUST FULL of thoughts about the Metal Congress and Exposition that will probably be over by the time you slit the wrapper on the November issue – but the only thing I could write now would be to prophesy about this and that and hope that all the details had been given consideration and not one forgotten.

Contrary to the common belief of my friends, I'm not busy at the time of the Congress and Exposition. In truth, I don't have anything much to do except look in on meetings, see that everything is running smoothly, observe the ladies having their demitasses in the morning and cocktails before lunch – all activities of a pleasant nature. We have learned long ago that if all preparations and plans are not minutely completed by the opening of the convention – IT'S TOO LATE! So, as I scribble these few lines, I keep hearing the rasping needle on the scratched record drumming aloud the convention secretary's theme song, "It's Later Than You Think".

So, thirty days ahead of the arrival of the first member to the 36th Annual Meeting, I'm in an office in the Palmer House, surrounded by three telephones, three secretaries, a printer, a sightseeing bus agent, the maitre d'hotel, the reservation clerk – in fact, the line forms outside on the right. However, all visitors are trying to be helpful and they really are. You may not meet them at Chicago, but they will have had a vital part in your ability to get a bus to the Show from your hotel every twenty minutes, or be able to sit down at lunch with 687 of your fellow members and not be short of a place to sit or food to eat.

However, I would not wish you to think that all the details and preparations are a 30-day operation. The date, hotel and exposition facilities are engaged six years ahead (back to Chicago in 1957 with a Second World Metallurgical Congress), while the Metal Show space-folders and invitations, preparation and preprinting of convention papers began well over one year ago. While we are now drawing floor plans for Philadelphia in '55, we also have contracts with hotels and Exposition buildings for Philadelphia again in '58. And so it goes – always a new challenge to create something that's new and advanced, which constantly keeps the on its toes and way up front.

I'll betcha the Chicago Congress and Metal Show will (or did) reach new heights for quality and attendance. One of the Best – 36 times better than the first one in Chicago in 1919. For a new feature, the 37th, coming up in Philadelphia Oct. 17 to 21, 1955, will top 'em all. If I am wrong (Heaven forbid), I'll set you up to a coke. See you in Philadelphia in '55.

Cordially yours,

W. H. EISENMAN, *Secretary*
AMERICAN SOCIETY FOR METALS

Bill

Whatever your furnace needs for control—

There's good reason why more heat-treating furnaces everywhere are controlled by Brown instruments. First, of course, is performance . . . sensitive, precise control that meets the most exacting requirements of modern heat-treating techniques. And equally important is versatility. In this varied line of instrumentation you'll find just about everything a furnace could possibly need in the way of control.

Just check through the requirements of your specific heat-treating problem . . . then look through this group of instruments and accessories:

Choose *ElectroniK* Strip Chart Controllers for detailed, long-term records . . . and a selection of control forms including electric systems of the contact, position-proportioning (*Electr-O-Line*) and time-proportioning (*Electr-O-Pulse*) types; and pneumatic control from two-position to full proportional-plus-reset-plus-rate action.

Choose *ElectroniK* Circular Chart Controllers for ease of scale reading . . . convenient daily charts; in a full range of electric and pneumatic control forms.

Choose *ElectroniK* Circular Scale Controllers where you want readability and control check at extreme distance . . . without need for a record. Supplied with all contact and proportional types of electric control.

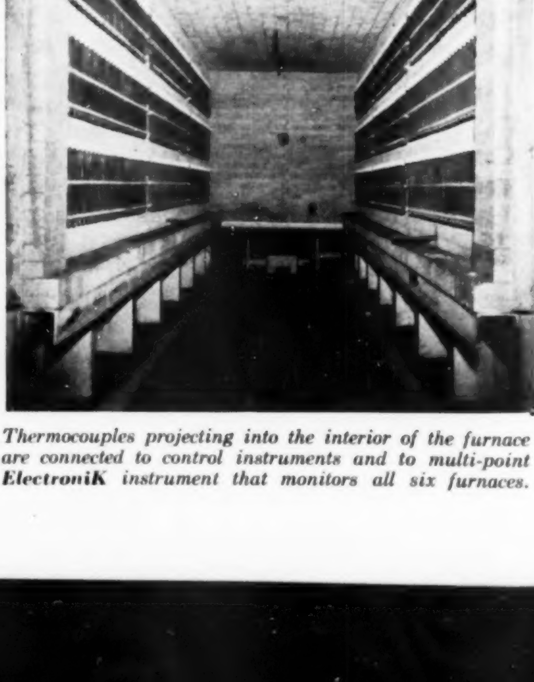
Choose *Pyr-O-Vane* Controllers where you don't need a record but do need precise vane type snap action electric control by a millivoltmeter instrument.

Choose *Protect-O-Vane* Controllers for simple, dependable excess temperature cut-off protection.

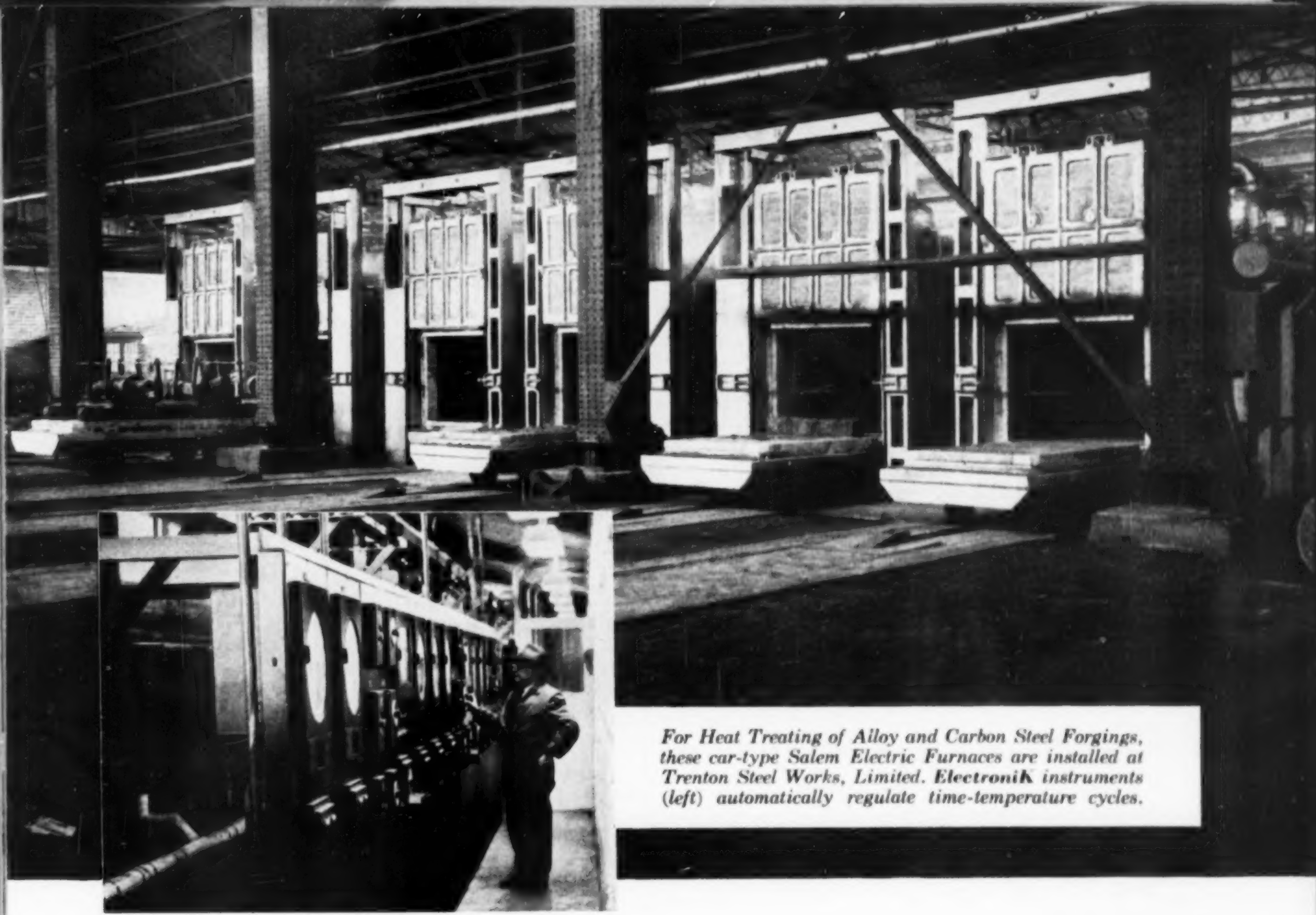
• • •

And for all your pyrometer supplies, investigate the HSM Plan —the convenient way to buy the best in supplies on a schedule custom-fitted to your plant . . . at advantageous discount schedules.

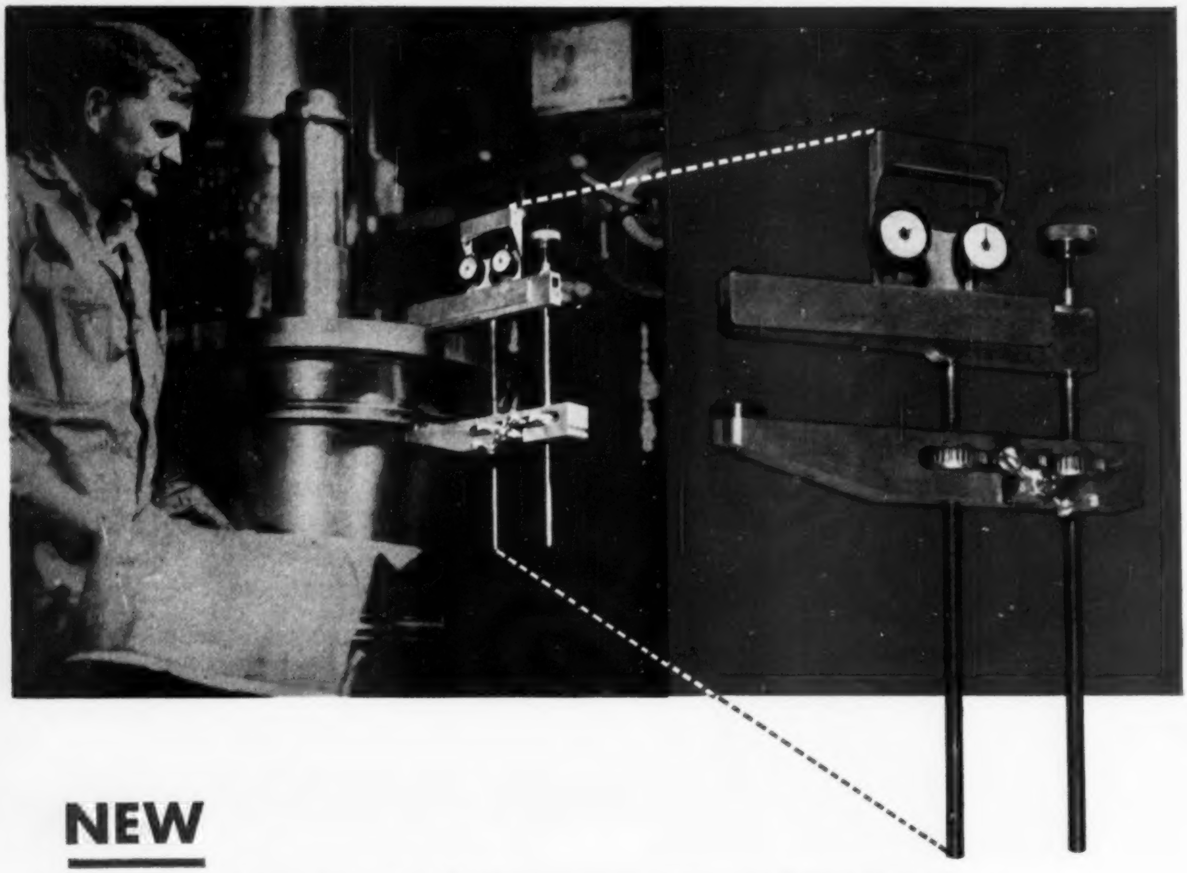
Big forgings get accurate Heat Treatment . . . *through*



*Thermocouples projecting into the interior of the furnace are connected to control instruments and to multi-point **ElectroniK** instrument that monitors all six furnaces.*



For Heat Treating of Alloy and Carbon Steel Forgings, these car-type Salem Electric Furnaces are installed at Trenton Steel Works, Limited. ElectroniK instruments (left) automatically regulate time-temperature cycles.



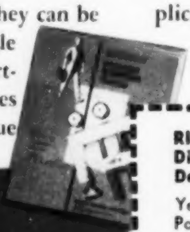
NEW

PORTABLE HARDNESS TESTERS MAKE TESTS ON THE SPOT

These new Riehle Portable Hardness Testers easily test *inside* and *outside* surfaces of parts inaccessible or difficult to test on bench machines. Riehle portables weigh but a few pounds. And each unit, plus included equipment, comes in a handy carrying case.

Riehle portables save the time *and expense* of cutting test specimens from heavy parts. They can be used horizontally, vertically, or at an angle without affecting accuracy. All Riehle Portable Hardness Testers offer Rockwell scales A, B, C, D, F and G — and insure a true Rockwell test. These testers use standard indentors with standard Rockwell loadings. There are no errors due to conversion from other scales.

Riehle portables are available in Models PHT-1 and PHT-2 which have respective capacities of $4\frac{1}{2}$ inches and 12 inches diameter or thickness. NEW FREE BULLETIN contains specifications and application photographs. Send for your copy.



Mail Coupon Today

RIEHLE TESTING MACHINES
Division of American Machine and Metals, Inc.
Dept. MP-1154, East Moline, Illinois

Yes, send me the new FREE Bulletin RH-12-54 on Riehle Portable Hardness Testers.

FIRM NAME

ADDRESS

CITY ZONE STATE

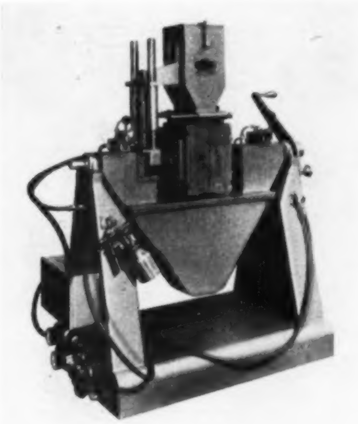
NAME AND TITLE

RIEHLE
TESTING MACHINES
Division of American Machine and Metals, Inc.
East Moline, Illinois

engineering digest OF NEW PRODUCTS

Shell Core Machine

A machine to produce shell cores for use with green sand, permanent and shell molds has been announced by Shalco Engineering Corp. It can deliver a completely cured shell core every 30 to 50 sec. depending upon core size and wall thickness. Available for either gravity investment, with sand hopper and shutter, or for blown cores, with a blow head, the shell core machine can be used with most existing core boxes. It has built-in heater plates which complete the



curing process on the machine itself, eliminating need for core dryers and ovens, and minimizing core handling. Operating cycle is simple on gravity investment machines, the sand hopper is lowered by pneumatic cylinder to the top of the core box. The sand-resin mixture is released by means of a shutter, and in cases of intricate cores, is slushed by rocking the core box assembly. The assembly is then inverted to allow excess sand mixture to return to the hopper for re-use. The hopper shutter is closed, the unit returned to normal position, and the hopper raised. When curing is completed, the core box is opened and core removed. On the blow-type machine, the core is blown, then inverted to recapture excess sand, and cured.

For further information circle No. 1615 on literature request card, p. 36-B.

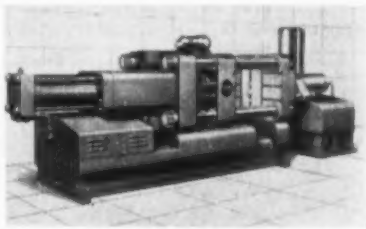
Electrocleaner

The Pennsylvania Salt Mfg. Co. has announced the introduction of a new, heavy duty electrocleaner. Recommended for use on steel and copper, K-8 will remove mill oil and smut prior to electroplating. It is a granular, anhydrous product containing 100% active ingredients which resist neutralization by acid soils and provide good electrical conductivity. Recommended for use at 4 to 12 oz. per gal. at 210° F. with 75 to 100 amps. per sq. ft. to take free advantage of its high conductivity, cleaning time will vary from ½ to 2 min. depending on the application.

For further information circle No. 1616 on literature request card, p. 36-B.

Die-Casting Machines

A new cold-chamber, high-pressure die-casting machine line was first displayed by Hydraulic Press Mfg. Co. at the National Metal Exposition in Chicago this month. Machines feature a new clamp design and new injection ends. The clamp is a combination of hydraulics and mechanics; hydraulics for smooth controlled movements and transmission of energy with simple mechanical linkage and wedge for multiplication of power. The injection end is a complete package power unit, including pump, motor and reservoir.



It features a special speed control operating valve that brings a variable acceleration and speed control to metal plunger action.

For further information circle No. 1617 on literature request card, p. 36-B.

Self-Balancing Indicator

Thermo Electric Co. has announced a new self-balancing indicator which makes it possible to read or log a great many temperatures quickly and accurately. It can be connected to several hundred thermocouples or resistance bulbs through connector panels,

Welder

A new, semi-automatic welding machine has been announced by the Amsco Div. of American Brake Shoe Co. The new machine feeds bare wire through a hand-held hopper containing magnetic flux. Flux clings to the wire as it leaves the hopper because of the magnetic field set up by welding current flowing through the wire. Thus the electrode wire, which is fed continuously from a coil, reaches the arc with a flux covering. The MF is easily connected to any conventional a-c. or d-c. welding machine and operates over a current range of from 150 to 500 amps. It consists basically of a hook-up cable, a small chassis mounting an electrode wire reel, motor-driven feed rolls, and a flexible 14-ft. tube through which the electrode wire feeds to a hand-held hopper. The portable model is provided with wheels for easy movement, and is pear-shaped to help in pulling it around the job.

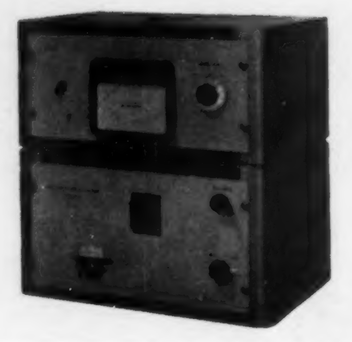
For further information circle No. 1618 on literature request card, p. 36-B.

toggle switches, or rotary switches. Its 34 in. scale is easy to read. Twenty-three ranges are available.

For further information circle No. 1619 on literature request card, p. 36-B.

Microspectrophotometer

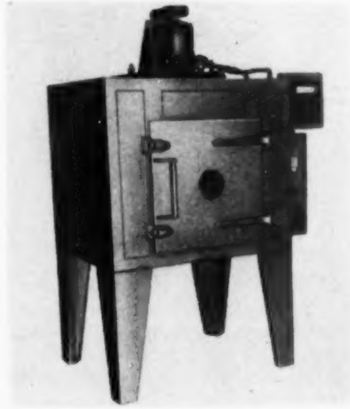
A new double-beam microspectrophotometer that can be used to analyze solutions in volumes ranging from as small as 0.015 ml. up to several milliliters has been announced by the Jarrell-Ash Co. A unique design feature allows the use of interchangeable micro and macro cuvettes of the appropriate volume and path length. The new instrument utilizes a single meter that is calibrated to indicate the ratio of the optical densities of concentrations. Operating on the double beam principle, the light is focused by a pair of mirrors onto two separate entrance apertures of the monochromator. A rotating alternator located in the plane of the entrance apertures chops the beams. The two light beams diverging from the apertures are then reflected by two parabolic mirrors to superimpose on a 30,000 line/inch grating. The dispersed radiation from the grating is picked up by a second pair of parabolic mirrors which focus each beam independently at separate exit apertures of the monochromator.



For further information circle No. 1620 on literature request card, p. 36-B.

Electric Oven

Steiner-Ives Co. has announced an electric oven, suitable for annealing, baking, brazing, curing, heat treating, normalizing, paint testing, processing, soldering. It has several banks of heaters which are controlled by a three-way selector switch for obtaining high, low or medium heat, as the particular job may require. A large volume of heated air is moved at high velocity about the work being treated. The interior size of the oven is 24 x 22 x 24 in. Temperature range is from 200 to 1000° F.



For further information circle No. 1621 on literature request card, p. 36-B.

Electronic Viscometer

Bendix Aviation Corp. (Cincinnati Div.) has announced an electronic viscometer for improving acid open-hearth furnace operations. The recommendations for use are as follows: Blend Bunker C fuel oil with suitable proportions of diesel oil by means of the electronic viscometer to reduce the

Just off the press—

THE HOW AND WHY OF BETTER QUENCHING WITH GULF SUPER QUENCH

GULF SERVES INDUSTRY

GULF OIL CORPORATION · GULF REFINING COMPANY

Room 1822, Gulf Building, Pittsburgh 30, Pa. MP

Gentlemen:

Please send me, without obligation, a copy of your new 24-page brochure dealing with the application and advantages of Gulf Super-Quench.

Name____

Title____

Company______________________________________

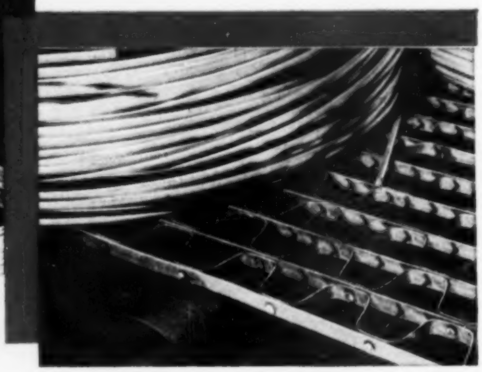
Address______________________________________

ROLOCK

FABRICATED ALLOYS

HEAT AND CORROSION RESISTANT

ONE-PIECE "KING SIZE" SERPENTINE FURNACE GRID



NOW SERVES KAISER ALUMINUM

This, we believe, is the largest single piece grid of its type ever produced . . . and three of them are now in use at the Newark, Ohio Works of the Kaiser Aluminum & Chemical Corporation.

Despite the extreme length of the carrier (25 feet), there is freedom from warpage, due to the "Serpentine" and tie-rod design as shown in the insert photo above. Type 304 stainless steel strip with rolled edges prevents marring the coiled aluminum rod through annealing at 900° to 950°F. and water-spray quench at 60° to 80°F.

The first Rolock 8 ft. serpentine grids performance-wise were a big improvement over previous carriers, but the present 25 ft. "King Size" gives complete stability on the conveyor through the spray quench cycle and reduces multiple handling costs significantly. Grids are 6 ft. wide each, providing 150 sq. ft. of usable surface.

As in this instance, Rolock engineers will gladly cooperate with yours in designing engineered-to-the-job equipment for heat treating and finishing processes. We've solved many tough jobs . . . and are looking for more. Ask for Catalog B-8 (Heat Treating) or B-9 (Corrosion Resistant).

Offices in: ANDERSON, IND., CHICAGO, CLEVELAND, DETROIT, HOUSTON, LOS ANGELES, MINNEAPOLIS, PHILADELPHIA, PITTSBURGH, ST. LOUIS

ROLOCK INC. • 1222 KINGS HIGHWAY, FAIRFIELD, CONN.

JOB-ENGINEERED for better work
Easier Operation, Lower Cost

10RL54A

sulfur content of the charge fuel, and maintain uniform viscosity and Btu. content. Use this fuel blend only until the slag forms on top of the melt; then use only Bunker C. Regulate the fuel atomization operation by maintaining the viscosity of the fuel oil at its

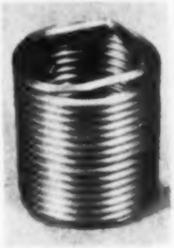
best through continuous control of the steam flow to the fuel oil preheater by means of another electronic viscometer. Uniform flame characteristics are thereby achieved.

The viscosity sensing probe is hermetically sealed and contains an explosive-proof junction box. It can be mounted by means of standard pipe fittings, directly into the feed line to the atomizing nozzles. The probe is connected to an electronic computer which translates the damping effect of liquids on the rugged vibrating reed of the probe into viscosity information.

For further information circle No. 1622 on literature request card, p. 36-B.

Screw-Lock Insert

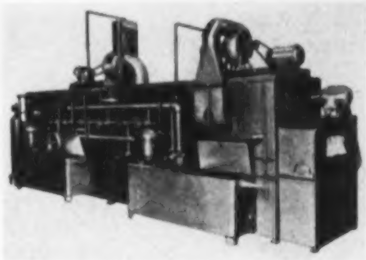
A new locking fastener designated as the screw-lock insert has been announced and displayed by the Heli-Coil Corp. at the National Metal Show in Chicago, Nov. 1 to 5. The screw-lock insert is formed stainless steel wire having a tensile strength of about 200,000 psi. It features a constricting area in the bottom coil which grips the screw. The locked screw may readily be freed by applying breakaway torque approximately the same as the torque used in making the original assembly.



For further information circle No. 1623 on literature request card, p. 36-B.

Cleaning Machine

A special cleaning machine using low-flash petroleum-type cleaning solvents has been announced by the Alvey-Ferguson Co. Parts, carried

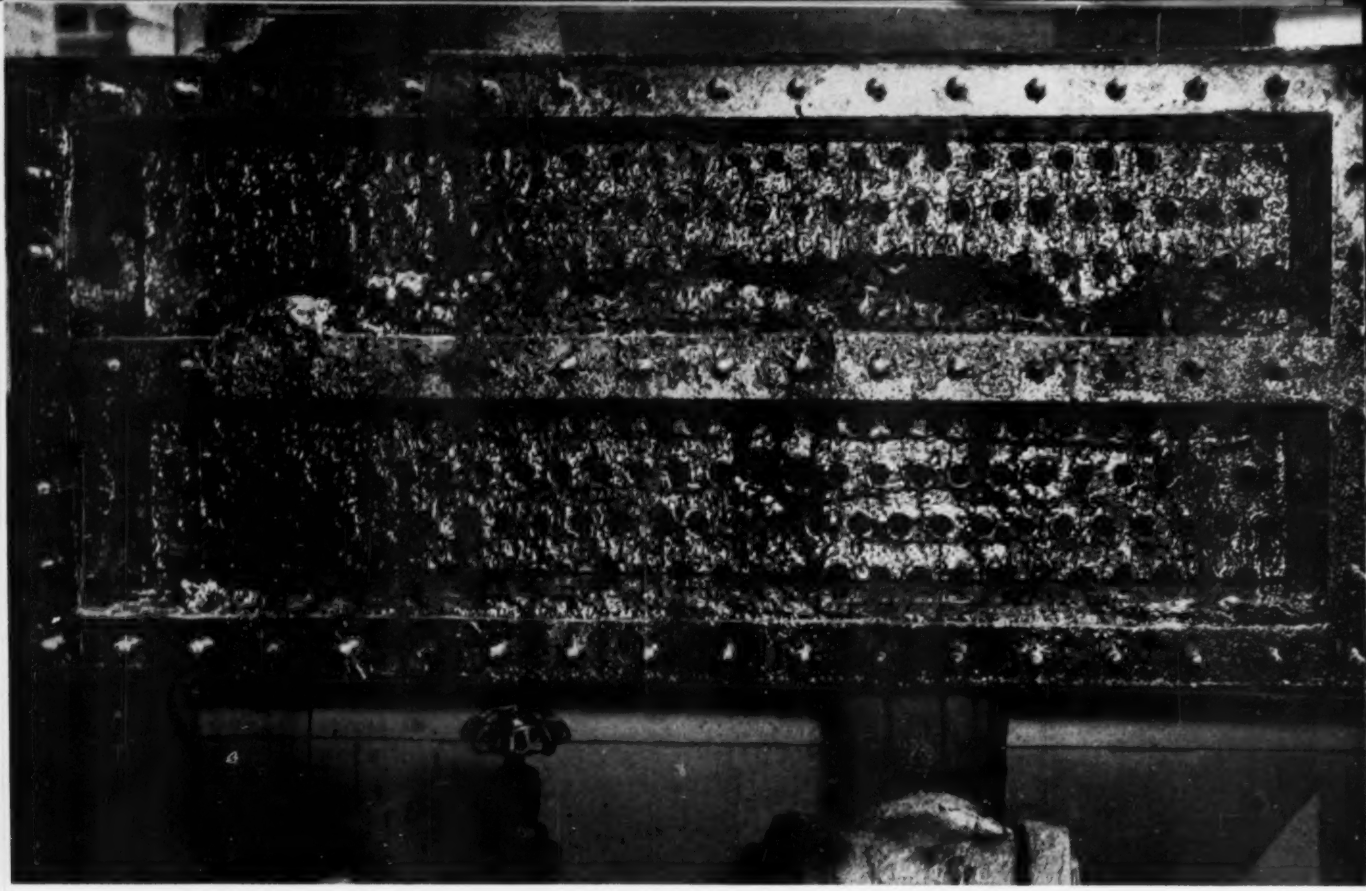


through the machine in baskets on a power driven roller conveyor, pass through consecutive high-pressure, fan-shaped curtains of low-flash petroleum-type solvent. Both emulsion and alkali cleaning solutions can be used in this machine. An automatic fire extinguishing and fire control system is standard equipment when machine is designed for use with petroleum-type solvents.

For further information circle No. 1624 on literature request card, p. 36-B.

Mixer

A new precision gas-air mixing and carbureting machine has been announced by the Waukee Engineering Co. It is supplied as a complete package with vane-type compressor, standard 1750 rpm. motor drive through V-belt, motor adjusting base, air

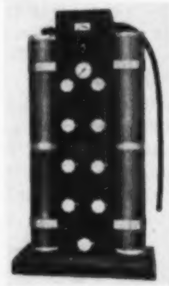


filter, pressure relief valve, gas zero governor, lubricator, carburetor and flow-meters mounted and factory piped. This unit may be used on gas generators of the endothermic and exothermic types and for producing

gas-air mixtures for flame hardening, torch annealing and soft metal melting. It is made in three sizes, rated for mixing capacity at 400, 600 and 1500 ft. per hr. and is available for city gas, natural gas, propane, butane, air.
For further information circle No. 1625 on literature request card, p. 36-B.

Demineralizer

A new bench model demineralizer has been announced by the Penfield Manufacturing Co. A completely packaged unit that requires only 15 x 8 in. of counter space, it is a regenerative type. The dual action design enables two columns to do the work of four. Raw water first is filtered through a stainless steel screen



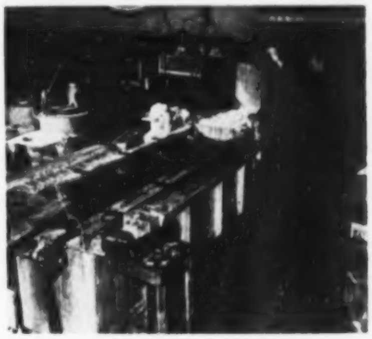
and then is given two complete demineralizations — passes through two columns, each of which contains both a cation resin bed and an anion resin bed — to produce a dually deionized effluent of less that 1 ppm. Regeneration is accomplished in less than 45 min. by turning a few valves located on the face of the control panel.
For further information circle No. 1626 on literature request card, p. 36-B.

Phosphate Coatings

Cowles Chemical has announced a new amorphous zinc phosphate coating. The coating cannot be removed, cracked, or damaged in any way by severe bending or flexing. It causes a chemical reaction on the metals being coated, integrating itself with the metals to form a denser harder coat for better, more complete rust-proofing.
For further information circle No. 1627 on literature request card, p. 36-B.

Salt Bath Furnaces

Electric shaver heads at Schick, Inc., are being austempered at the rate of approximately 30,000 pieces per day with rejects due to cracks held to less

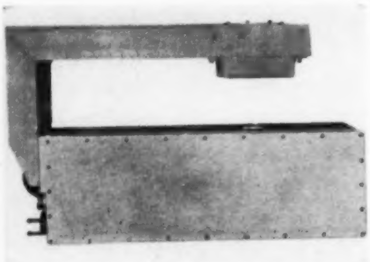


than 0.05%. Shaver heads, the outer head 0.003 in. thick, are stamped from special high carbon steel. The

outer head has 128 slots in the ¼ by 1⅛ in. cutting plane. With such delicate shapes, distortion cannot be tolerated. An Ajax Electric salt bath isothermal quenching furnace, with working dimensions 10 by 2 ft. by 22 in. was installed between the austenitizing bath and the rinse tank. The new cycle for austempering heads consists of a 5-min. preheat, 5 min. immersion in a 1550° F. austenitizing bath, 1½ hr. in the isothermal quenching furnace at 550° F., followed by a cold water wash. In addition to reducing cracks and effecting the savings, distortion is held within limits, six processing operations have been eliminated, and hardness is uniform.
For further information circle No. 1628 on literature request card, p. 36-B.

X-Ray Gage

An X-ray thickness gage for gaging aluminum foil as thin as 0.0003 in. and steel as thick as 0.075 in. with accuracies of 1% has been announced by Pratt & Whitney Div. of Niles-Bement-Pond Co. The X-ray gage utilizes a split X-ray beam, directing part of the beam through a wedge



shaped disk, having a variation in thickness equal to the range of the gage, while the remainder of the beam penetrates the material being gaged. As the strip progresses through the mill, a difference in thickness between the wedge and the gaged material will cause the electrical balance system to equalize them by revolving the wedge and thus show a meter reading equivalent to this thickness change. A recorder may be placed in the circuit to give direct reading of the absolute thickness of the material passing through the gage head.
For further information circle No. 1629 on literature request card, p. 36-B.

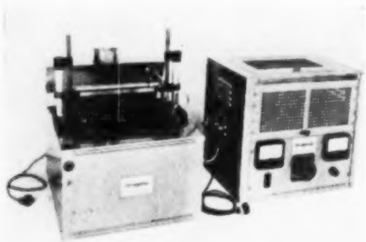
Annealing Basket and Carrier

The Wiretex Mfg. Co. has announced a special all-stainless steel basket and carrier designed to hold sma'l brass or other parts while they go through the annealing process. The 12 x 28 in. basket is completely welded and can hold up to 600 lb. of metal. Heavy lugs are welded to the upper rim to act as grippers and stacking guides. Usually, three baskets are stacked together in the large carrier,

the bottom basket resting on the carrier angle frame. Parts are kept in the same basket for most of the operations, from machining through annealing, to packing and shipping.
For further information circle No. 1630 on literature request card, p. 36-B.

Chromium Plating

Dawson Corp. has announced a new hard chromium plating unit which makes use of an improved plating solution eliminating the necessity of bath adjustment or maintenance throughout the life of the solution. It will deposit a bright, hard chromium plate as fast as 0.002 in. per hour on areas up to 25 sq. in. The unit itself is a complete package. It contains a 12 by 12 by 11 in. tank, exhaust hood, adjustable work plat-



form and thermostatically controlled electric heater. A special feature is the rectifier which embodies all the necessary plating controls. All types of metal may be plated, including sintered carbides and aluminum.
For further information circle No. 1631 on literature request card, p. 36-B.

Casting Titanium

A new process for making titanium castings, involving the use of vacuum and an inert atmosphere has been announced by National Research Corp.

An important message concerning a new —and unique— alloy steel

UNITED STATES STEEL is pleased to announce to all steel consumers a new steel which we feel sure will enable you to improve the performance, lengthen the life, and reduce the cost of industrial equipment. This new engineering material is USS Carilloy T-1 steel, which recently underwent some very severe testing in Birmingham, Alabama.

The development of T-1 steel began back in 1947, when our research people took a good look at a problem that had plagued alloy plate steel users for years. That problem was the multiplicity of compositions required to do everyday jobs. There was no one composition available that could serve a wide variety of applications—so our research people set out to develop such a steel. The steel we wanted had to possess many unusual attributes such as very high strength, unusual toughness, good weldability and excellent resistance to impact abrasion at temperatures from minus 150°F. up to as high as 900°F.

Today such a steel is a reality. It is USS Carilloy T-1 steel, which has been tested thoroughly, both in the laboratory and in actual service applications. To prove further the capabilities of this new Carilloy steel, Chicago Bridge & Iron Company and United States Steel this summer carried out a joint testing program on commercial pressure vessels built from T-1 steel. The results of these tests and their significance to all steel users are described on the next three pages. We feel sure that you will find the story well worth reading.

USS

TRADE MARK

UNITED STATES STEEL

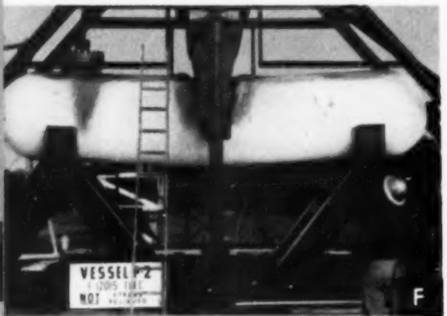
USS CARILLOY T1 STEEL

DOWN TO 38°F. BELOW ZERO

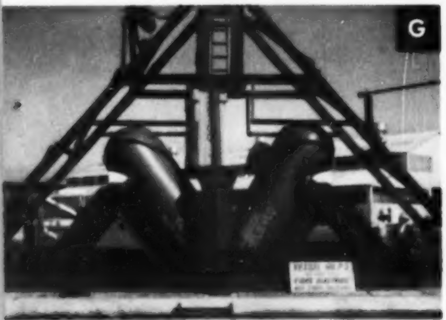
E 12015 low hydrogen coated electrodes. The other four were welded with E 9015 electrodes and were stress relieved after welding. Two vessels of each type were given two tests: a pressure burst test for strength and ductility, and an impact punishment test for toughness and resistance to the most severe impact conditions that could be devised.

Results of these tests, described below, prove conclusively the exceptional strength and toughness of USS Carilloy T-1 steel, even at temperatures far below freezing.

E



F


G

H

Frozen steel vessel made of Carilloy T-1 survives blow from 13-ton ingot dropped 73 ft.

A steel ingot weighing 26,700 lbs. has just plummeted 52 feet and crunched on top of this test vessel (Fig. E). The ingot was traveling 39 miles per hour when it hit. It struck with an impact energy of about 1,400,000 ft. lbs., bounced fifteen feet, and crushed down again on top of the vessel.

This vessel was welded without stress relieving. It was refrigerated to 33°F. below zero. It was pressurized to 1,875 psi. equal to a stress on the plates of 90,000 psi.—the steel's *nominal* yield strength. Yet, it did not fail. The ingot left only a 7/16 inch dent in the top, with a slight bulge on either side of the dent.

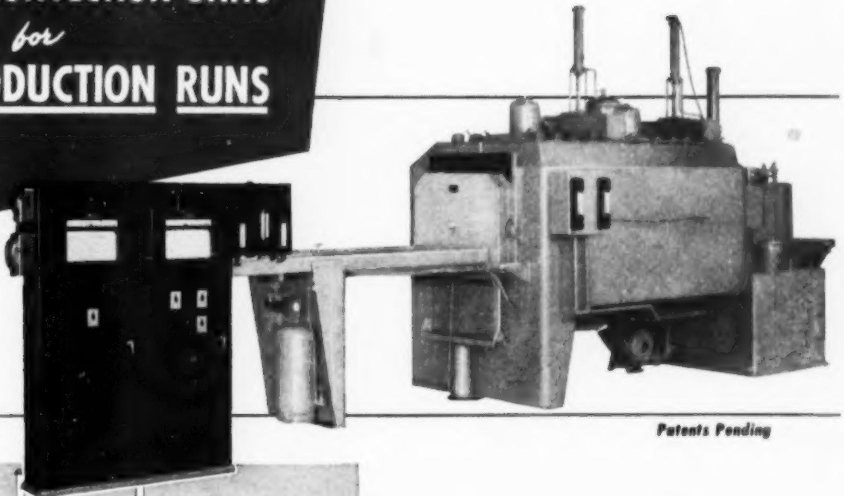
The test was repeated (Fig. F). This time the ingot was raised 73 feet, then dropped. It pounded down again on the very same spot on top of the vessel. Traveling at 46.7 miles per hour, it hit with an impact blow of 1,960,000 ft. lbs. The dent merely deepened — the steel and all welds were still intact.

Again the test was repeated (Fig. G). Now dropped from 101 feet, the 13-ton ingot ploughed into the top of the vessel at a speed of 55 miles per hour, hit with an impact of 2,750,000 ft. lbs. This time the vessel failed. But it didn't shatter. It didn't crack. It tore open like a tough piece of hickory. In other words, it failed without any signs of brittleness, even though the temperature of the steel was now minus 22°F.

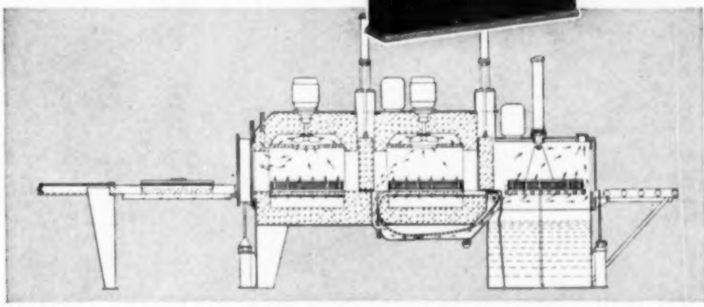
In addition to this tremendous resistance to impact abuse, combined with remarkable sub-zero toughness, Carilloy T-1 steel also gives you excellent resistance to impact abrasion . . . good high temperature strength . . . and exceptional weldability.

Turn the page to see how you can use this remarkable new steel to cut costs and improve performance in a great variety of products.

100% FORCED CONVECTION UNITS *for* Heavy PRODUCTION RUNS



Patents Pending



◀ The Ipsen 800 Lb./Hr. Automatic Heat Treating Unit. Features two heating chambers. Hearth dimensions are 24" wide x 36" long x 18" deep. Maximum operating temperature is 1850° F.

Ipsen STANDARD UNITS NOW AVAILABLE UP TO 2000 LB./HR. CAPACITY

Shown above is the Ipsen 800 Lb./Hr. Automatic Heat Treating Unit, typical of a proven line of furnaces designed for heavy production requirements. The Ipsen T-800 economically provides quality heat treatment of a larger volume of workpieces . . . from smallest screws to the largest gears. Among advanced engineering features of the T-800 are:

1 **Automatic Loader**—which also acts as transfer mechanism to move work load from first to second heat zone without loading delays. Movement of load from second zone to cooling-quench chamber is done automatically by Ipsen cold chain drive.

2 **Totally Enclosed Cooling-Quench Chamber**—Controlled atmosphere in both heat and quench zones gives you bright, scale-free results.

3 **Two Independent Heating Chambers**—with separate controls. Heating by radiant tubes, located in back of baffles, eliminates radiation from tubes to workpieces. 100% forced convection heating!

4 **Engineered for Versatility**—Each self-contained Ipsen Metal Treating Unit can harden, carburize, carbon restore and carbonitride.

For More Data—Write today for specifications and descriptive literature. If you desire, send samples of your work for processing and for an estimate of cost.

AUTOMATIC Ipsen HEAT TREATING UNITS

IPSEN INDUSTRIES, INC. 723 SOUTH MAIN STREET, ROCKFORD, ILLINOIS

The small vacuum furnace now in operation can produce castings weighing 4 or 5 lb. with a finish equivalent to that of good sand castings. Casting procedures are similar to general foundry practice of stainless alloys. Some unusual steps include the following: The mold is given a special treatment which enables it to withstand the action of molten titanium. Melting is done in vacuum with an argon atmosphere. Mold is cooled in the furnace under argon or vacuum so that the titanium is solidified before coming in contact with the atmosphere.
For further information circle No. 1632 on literature request card, p. 36-B.

Joining Nonferrous Wire

The Utica Drop Forge & Tool Corp. has announced Buttweld tools which will weld different sizes of the same or dissimilar nonferrous metals without the use of heat, electricity or chemicals. The tools are plier-action operated. They weigh 5 lb. and are 14 in. long. The KB-14B tool will weld aluminum and copper, and aluminum to copper wire in a range from 0.039 in. up to but not including 0.063 in. The KB-14 tool will handle copper wire from 0.063 to 0.089 in. and aluminum and aluminum to copper wire in a range 0.063 in. to 0.127 in.

For further information circle No. 1633 on literature request card, p. 36-B.

Cold Treatment

Bowser Technical Refrigeration has announced a new line of cold treatment units for testing, storage and processing applications. Featuring rapid temperature pulldown, the new units operate within a range from −60 to −170° F. Semihermetic compressors are standard on all models, and a fan and coil arrangement permits air circulation within the cold chamber. Units are available with casters for portable operation.

For further information circle No. 1634 on literature request card, p. 36-B.

Enameling Aluminum

Parker Rust Proof Co. has announced a new pre-enameling product for aluminum. Since the adhesion of porcelain enamel to untreated aluminum is poor on the alloys normally used a chemical coating must be applied before the enamel. Prefiring is unnecessary when using this treatment. The bath is controlled by simple chemical tests and can be used indefinitely. Results of control tests indicate the bonding effectiveness of Pre-Namel 420 and its resistance to weathering.
For further information circle No. 1635 on literature request card, p. 36-B.

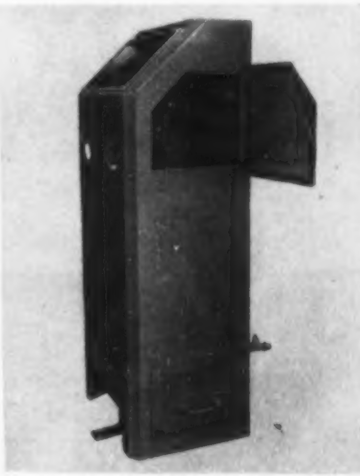
Controlled Pouring Speed

Ecco High Frequency Corp. has announced a new technique for the accurate control of speed of pouring metal from its high-frequency roll-over induction furnaces. A predetermined pouring speed is obtained by means of a hydro-motor drive which in turn is driven by a regulated hydraulic power source built into the unit. This drive insures duplication of pours irrespective of mold weight or other variables. Furnaces are available to accommodate crucibles for 5, 10, 15 and 25 lb. melts.

For further information circle No. 1636 on literature request card, p. 36-B.

Sand Blasting

A newly redesigned sand blasting machine has been announced by Leiman Bros. Special features include an extra-large, full-width viewing glass, giving full vision of interior; fully enclosed cabinet design; and movable nozzle suspended from top of cabinet. It is available in three stock sizes: 18 x 24 in., 30 x 36 in., and 24 x 60 in., or custom built. Automatic feed for small parts such as nuts, bolts is another feature.



For further information circle No. 1637 on literature request card, p. 36-B.

Induction Heating

A new motor generator control and heating station has been announced by Lindberg Engineering Co. for forging, hardening, brazing or annealing operations where deep penetration of heating is desired. The station has been designed to enable metering to be located on either the front, right or left side. A constant check on air temperature, water temperature, high voltage interlocks, water flow and other operating conditions is maintained. Operations may be timed automatically by means of a four circuit synchronous timer capable of control-

For years the metal industry has benefited by the growth of metallic sodium as a reaction tool. An early commercial process for aluminum depended on this versatile element and now the processing of stainless steel and other metals depends upon the rapid, efficient Sodium Hydride Descaling Process.

Today sodium makes possible new or improved methods for producing titanium, zirconium, silicon, tantalum, hafnium and many others. Ductile metal and finely divided metal powder catalysts can be made from metal salts and oxides.

"Argon Grade" Metallic Sodium — produced, specially filtered and packed in an atmosphere of argon gas — has been developed by engineers in our Ashtabula, Ohio plant. Sodium protected in this manner is recommended for use where traces of dissolved gases such as oxygen and nitrogen interfere with the preparation of pure metals.

This is our latest step in developing forms and grades of metallic sodium which are easy to use and acceptable for many industrial applications.

Don't overlook sodium for your processes! We offer specialized technical service on adapting sodium to your particular needs. Fill out the coupon below so that we can help you make profitable use of metallic sodium.

Metallic Sodium is manufactured by National Distillers Chemical Co. at Ashtabula, Ohio and sold by:

U.S. INDUSTRIAL CHEMICALS CO.

Divisions of National Distillers Products Corporation
99 Park Avenue, New York 16, N. Y. Branches in principal cities

NATIONAL DISTILLERS CHEMICAL CO.

I NEED INFORMATION ON SODIUM FOR ____________________

NAME ____________________

COMPANY ____________________

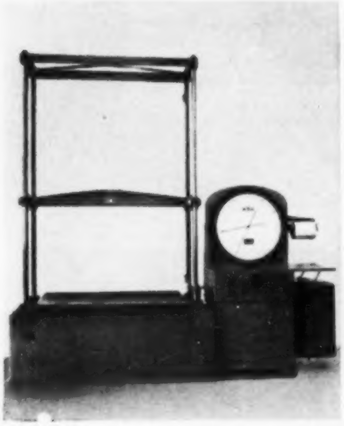
ADDRESS ____________________

ling three operations in addition to the heat cycle. Vernier adjustments are furnished on the first three positions for accurate heat, quench and capacitor contactor.

For further information circle No. 1638 on literature request card, p. 36-B.

Spring Testing

A new 10,000 lb. spring testing machine for compression testing of complete spring assemblies has been announced by Tinius Olsen, Inc. Load



is weighed by means of an equal set of levers mounted directly under the table of the testing machine in combination with an electronic indicating system. Loading is accomplished by an electro-mechanical system with four rotating screws. Positive and infinite loading speeds from 0.025 to 8 in. per min. are maintained by a variable speed drive. Standard columns permit testing of a 72-in. compression specimen.

For further information circle No. 1639 on literature request card, p. 36-B.

High-Low Temperature Unit

Webber Mfg. Co. has announced a new test chamber for high-volume production testing. Two compartments of 1 cu. ft. capacity each have a temperature range of −100 to

+200° F. with a gradient temperature variation of less than 0.5° at any point within the chambers. The design uses a special solenoid-type control in conjunction with the patented refrigerating system and a proportioning temperature control instrument. A propeller fan system in each chamber recirculates the air through the chamber and over the refrigeration coils or heating elements, changing the air 500 times per minute. Test chambers may operate independently of each other even at extreme temperature differences.

For further information circle No. 1640 on literature request card, p. 36-B.

Straightener

Sutton Engineering Co. has announced a new machine for straightening tubes from ½ to 3½ in. o.d. in varying lengths. It is equipped with entry and exit tables. The straightening process operates either as a completely automatic cycle of feed and delivery or manually. Straightening unit employs the 5-roll principle of straightening in which a central pressure roll is located between two sets of opposed rolls, each set having one driven roll and one idler roll. It is powered with a 20 to 25 h.p., 230 volt d.c., 450 to 1800 r.p.m. continuous duty motor, and operates at straightening speeds from 60 to 240 ft. per min.

For further information circle No. 1641 on literature request card, p. 36-B.

Dual-Fuel Burner

Dual-fuel burners that operate under a wide variety of conditions on heavy oil, light oil or gas have been announced by the North American Mfg. Co. The nozzle-mix sealed-in burners are suitable for general use on all types of furnaces. The series is

offered in three sizes having 4, 6 and 8 in. main air connections. Smaller and larger sizes are being developed. The burners may be operated double rich on gas or light oil; with heavy oil, atomization becomes a problem if the burners are operated over 50% rich. Also, they may be run very lean by leaving the air on full and turning the fuel input down to 1/5 of normal for oil, ⅓ for gas.

For further information circle No. 1642 on literature request card, p. 36-B.

1645. Abrasion Tester
Bulletins on durable precision instrument for evaluating the resistance of surfaces to rubbing abrasion. *Taber Instrument*

1646. Abrasive Wheels
Operating suggestions and recommended wheels for finishing stainless. *Manhattan Rubber Div.*

1647. Air-Gas Mixer
Bulletin L-700 gives engineering and application data on air-gas proportional mixer. *Eclipse Fuel Eng'g*

1648. Alloy Castings
22-page bulletin 2041 on heat and corrosion resistant castings. *Blaw-Knox*

1649. Alloy Steel
16-page book on type 9115 low-alloy high-strength steel. Properties, fabrication, welding. *Great Lakes Steel*

1650. Alloy Steel
68-page "Aircraft Steels" includes revised military specifications. Also stock list. *Ryerson*

1651. Alloy Steel
Data book on the selection of the proper alloy steel grades for each manufacturer's needs. *Wheelock, Lovejoy*

1652. Alloy Steels
Comparative tables of SAE and AISI standard steels and tentative standard steels. *Babcock & Wilcox*

1653. Aluminum Alloys
36-page book on analysis of aluminum, brass, bronze alloy specifications. *Sonken-Galamba*

1654. Aluminum Die Castings
Bulletin on design and manufacture of aluminum die castings. *Hoover Co.*

1655. Aluminum Extrusions
28-page book on extruded aluminum products. Design, tolerances, applications. *Revere*

1656. Aluminum Heat Treating
Bulletin on furnaces for aging, annealing, heat treating and forging aluminum. *Morrison Eng'g Corp.*

1657. Aluminum Forgings
Folder on advantages of forgings in many applications. *Bridgeport Brass*

1658. Aluminum Strip
20-page booklet on how it is made, sizes and weights of coils. Technical data on aluminum alloys used. *Scovill*

1659. Ammonia Dissociators
Bulletin on dissociating process gives advantages of ammonia as controlled atmosphere. *Sargeant & Wilbur*

1660. Annealing Furnaces
8-page illustrated booklet on continuous annealing furnaces. Schematic diagrams, photographs, and actual production data. *Drever*

1661. Architectural Aluminum
16-page booklet on aluminum products for architectural use, aluminum structural shapes, embossed finishes on aluminum. *Reynolds Metals*

1662. Atmosphere Furnaces
Information on mechanized batch-type atmosphere furnaces for gas cyaniding, gas carburizing, clean hardening or carbon restoration. *Dow Furnace*

1663. Atmospheres
Bulletin 1-10 supplies technical information on inert gas generators and data on costs. *C. M. Kemp Mfg.*

1664. Atmospheres
Bulletin 439 on exothermic atmosphere generators for converting natural gas, manufactured gas, propane or butane. *W. S. Rockwell*

1665. Austempering
Discussion of austempering after gears have been finish machined. *Ajax Electric*

1666. Basic Materials
24-page booklet on Alundum, Crystolon, Magnorite, Norbide, zirconia, carbides, borides and other basic materials. Products made from them are listed. *Norton*

1667. Bending and Cutting
Folder describes hand and air-operated bender-cutter and its applications. *J. A. Richards*

1668. Beryllium Copper
16-page booklet on applications and properties of beryllium copper. *Beryllium Corp.*

1669. Black Oxide Finish
Folder on penetrating black finish for ferrous metal. *Puritan Mfg.*

1670. Blast Cleaning
16-page bulletin 226 on continuous flow Rotoblast cleaning barrels. *Pangborn*

1671. Brass Bearings
New 24-page catalog on 600 series bearing alloys. Description of alloys, typical parts, properties, machining. *Mueller Brass*

1672. Brazed Tubing
12-page data book on brazed tubing made from copper coated steel. *Bundy*

1673. Brazing
50-page text GEA-3193 describes the methods and applications of electric-furnace brazing. *General Electric*

1674. Burners
16-page bulletin on selection of gas burners. *Western Products*

1675. Carbon Analysis
Folder describes method of rapid carbon determination. *Leitz*

1676. Carbon Control
Bulletin C-22 and reprint on Carbotronik for automatic control of carbon potential of atmospheres. *Ipsen*

1677. Carbon Control
New 12-page catalog TD4-620(2) on Microcarb atmosphere control for control of carbon potential in Homocarb furnaces. *Leeds & Northrup*

1678. Carbonitriding
Literature on Ni-Carb (carbonitriding) treatment for surface hardening. *American Gas Furnace*

1679. Casehardening
Bulletin 159 describes standard rated batch furnaces for case hardening. *Surface Combustion*

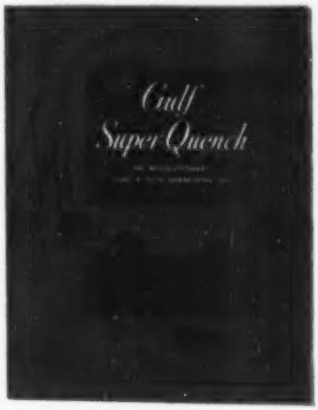
1680. Casehardening
32-page booklet on casehardening of steel by nitriding. *Armour Ammonia Div.*

1681. Castings
32-page brochure on manufacture of steel castings from design and pattern making to applications. *Lebanon*

1682. Cemented Carbides
16-page bulletin gives mechanical and physical properties of carbides for tools and high-temperatures. *Kennametal*

1644. Quenching

An important new book for those who heat treat metal or are interested in the heat treating process is "Gulf Super-Quench, the Revolutionary Dual-Action Quenching Oil." Accompanying a clear concise discussion of such subjects as the mechanism of heat removal



during quenching, properties of an ideal quenching medium, effect of increasing degree of agitation, the hardenability of steels, effect of mass on depth of hardening and distortion and cracking are 24 figures, including cooling curves and transformation diagrams, and 4 tables. *Gulf Oil Corp.*

1683. Centrifugal Castings
Booklet on spun centrifugal castings of bronze for liners, rings, rolls, sleeves, bushings. *American Non-Gran Bronze*

1684. Chromate Coatings
Folder gives characteristics and uses of chromate conversion coatings on nonferrous metals. *Allied Research*

1685. Chromium Plating
Booklets on how to chromium plate and anodes for the process. *United Chromium*

1686. Cleaners
Bulletins on di-phase cleaners, specifications, equipment, advantages. *Solventol*

1687. Cleaning
32-page booklet on alkaline, solvent, emulsion, acid phosphate cleaning. *E. F. Houghton*

1688. Cleaning
Bulletin on equipment for cleaning and pickling of shell cases and other ordnance items. *Alvey-Ferguson*

1689. Cleaning
Data sheets on acid activators to promote removal of scale and oxides from steel and iron. *Swift Ind. Chem.*

1690. Cleaning
44-page booklet, "Some Good Things to Know About Metal Cleaning", discusses tank, barrel and machine cleaning, pickling, zinc phosphate coating, rust prevention and other processes. *Oakite*

1691. Cold Rolled Steels
32-page booklet on stainless, alloy and carbon spring steels, and other specialties. Melting, temper, finishes. *Crucible Steel*

1692. Combustion Control
20-page booklet on combustion of various fuels and portable instrument to measure content of oxygen and combustibles. *Cities Service Oil*

1693. Compressors
12-page bulletin 126-A on application of turbo compressors to oil and gas-fired equipment used in heat treating, agitation, cooling, drying. Performance curves, capacities. *Spencer Turbine*

1694. Controlled Atmospheres
24-page bulletin describes production problems with reference to dry atmospheres. *Pittsburgh Lectrodryer*

1695. Controllers
80-page catalog 8305 on nonindicating electric, electronic and pneumatic controllers for temperature, pressure and humidity. *Minneapolis-Honeywell*

1696. Copper
Report on supply of copper, mine production, scrap utilizations, importation, reserves. *Copper & Brass Research Assoc.*

1697. Cutting Oil Chart
Selection chart for seven classes of metal in nine machining operations. *Aldridge Industrial Oils*

1698. Decarb Test
Simple test for decarburization described in Tips and Trends. *Ajax Electric*

1699. Deep Drawing
Reprint on new deep drawing technique involving single-stroke dies and eliminating intermediate operations. *Schnell Tool & Die*

1700. Degreasing
34-page booklet on vapor degreasing. Design, installation, operation and maintenance of equipment. *Circo Equipment*

1701. Die-Casting Machines
Copies of "Lester Press" describe various features of aluminum die casting machines. *Lester-Phoenix, Inc.*

1702. Die Steel
Bulletins on air-hardening, high-carbon, high-chromium die steel containing sulphide additives. *Latrobe*

1703. Ductile Iron
Reprints on engineering applications of ductile iron and its significance to the foundry industry. *Youngstown Foundry & Machine*

1704. Electric Furnace
Bulletin on box-type, pre-heat and hardening furnace with automatic atmosphere contamination control. *Pacific Scientific*

1705. Electric Furnaces
8-page booklet on belt conveyor electric furnaces for bright hardening. *Westinghouse Electric Corp.*

1706. Electric Furnaces
Brochure on electric heat treating, melting, metallurgical tube, research and sintering furnaces. *Pereny Equipment*

1707. Electric Furnaces
New bulletin on electric heat treating furnaces gives summary of progress in furnace developments. *Holcroft*

1708. Electroforming
Bulletin on production of intricate parts and precision components by the electroforming process. *Bart Labs.*

1709. Ferro-Alloys and Metals
104-page book gives data on more than 50 different alloys and metals produced by the company. *Electro Metallurgical*

1710. Filters
Bulletin on application of industrial filters to oil quenching process. Experience with two applications. *Industrial Filtration Co.*

1711. Finishing
52-page book "Advanced Speed Finishing" describes equipment for deburring and finishing. *Almco Div.*

1712. Flame Hardening
20-page booklet on precision flame hardening machine with electronic control. Details of operation and application. *Cincinnati Milling Machine*

1713. Flaw Detection
Illustrated bulletin on Spotcheck, new dye-penetrant method for locating surface defects. *Magnaflux*

1714. Flow Meters
24-page manual on application and installation of indicating flow meter. *Meriam Instrument*

1715. Flow Meters
Bulletin 201 on flow meter for gas used in heat treating. *Waukee Eng'g*

1716. Forging Design
16-page book on design of forgings covers purpose, forging tools, design for drop forgings, press forging design, economy tips. *Globe Forge*

1717. Forgings
16-page brochure on steel drop, upset and press forgings. *Amforge Div., American Brake Shoe*

1718. Forgings
94-page book on die blocks and heavy-duty forgings. 20 pages of tables. *A. Finkl & Sons*

1719. Forming
86-page book on equipment and process of cold roll-forming. Wide sheets, narrow trim, tubular shapes, curving, coiling, tooling needed. *Yoder*

1720. Forming Dies
Folder on styles of forming dies for stainless heads—in wide range of sizes and gages. *Carlson*

1721. Forming Equipment
Bulletin on machinery and equipment for cold roll forming. *American Roller Die*

1722. Foundry Supplies
Bulletin on Zirconite sand, flour, mold and core wash. *Titanium Alloy Mfg. Div.*

1723. Freezers
Bulletins on environmental chambers from cold only to fully instrumentated all weather environmental installations. *Conrad, Inc.*

1724. Furnace
Bulletin on Karbo-matic furnace for carbonitriding, dry cyaniding or automatic hardening. *Pacific Scientific*

1725. Furnace Arches
Bulletin on sectionally suspended circular arches for rotary hearth furnaces. *Geo. P. Reintjes*

1726. Furnace Belts
44-page catalog describes metal belts for quenching, tempering, carburizing and other applications. *Ashworth Bros.*

1727. Furnace Construction
12-page bulletin on thin-wall construction for furnace enclosures. Engineering drawings. *Bigelow-Liptak*

1728. Furnace Controls
22-page booklet on instruments and controls for heat treating furnaces. *Hays Corp.*

1729. Furnace Insulation
Bulletin on ceramic fiber that can give impressive savings compared with high-quality insulating brick. *Refractories Div., Carborundum Co.*

1730. Furnaces
Catalog of gas or oil fired heat treating and melting furnaces. Conveyor type, pot furnaces, atmosphere furnaces. *Barkling Fuel Engineering*

1731. Furnaces
8-page bulletin on continuous, car-type, reverberatory, recirculating and other furnaces. *Demsey Industrial Furnace*

1732. Furnaces
High temperature furnaces for temperatures up to 2000° F. are described in bulletin. *Carl-Mayer Corp.*

1733. Furnaces
Data on electric furnaces of top or side loading types. *Lucifer Furnaces*

1734. Furnaces
16-page Bulletin 135 on industrial furnaces and atmosphere generators. Continuous systems. *Continental Industrial Engineers*

1735. Furnaces
16-page bulletin 81 on recirculating furnaces for stress relief, heat treating, preheating. *Despatch Oven*

1736. Furnaces
12-page brochure on car furnaces of special and conventional design. *Jet Combustion*

1737. Furnaces
32-page catalog of heat treating and forging furnaces, blowers, melting furnaces, control equipment and accessories. *Johnson Gas Appliance*

1738. Furnaces
Folder describes complete set-up for heat treatment of small tools, including draw furnace, quench tank and high temperature furnace. *Waltz Furnace*

1739. Furnaces, Heat Treating
Catalog on furnaces for tool room and general purpose heat treat. *Cooley*

1740. Furnaces, Heat Treating
12-page bulletin on conveyor furnace, radiant tube gas heated, oil or electrically heated. *Electric Furnace Co.*

1741. Furnaces, Heat Treating
32-page catalog on high-speed gas furnaces for heat treating carbon and alloy steels; also pot furnaces for salt and lead hardening. *Charles A. Hones*

1742. Furnaces, Heat Treating
Bulletin on furnaces for annealing, normalizing, hardening, tempering, forging. *Flinn & Dreffein Eng'g*

1743. Gamma Radiography
8-page catalog on gamma-ray radiography with radioactive cobalt 60 and iridium 192. *Mitchell Radiation Products*

1744. Gamma Radiography
Data file on equipment and sources for cobalt 60 radiography in industry. *Technical Operations*

1745. Gas Analysis
Bulletin on gas analyzer based on principle of thermal conductivity. *Charles Engelhard*

1746. Gas Analysis
Data on positive, nondispersion-type infrared analyzers for laboratory and industry. *Minneapolis-Honeywell*

1643. High-Strength Steel

This new 48-page book discusses Carilloy T-1 steel, its properties and applications. Costs are analyzed for different uses and fabricating procedures. Recommendations for pressure

vessels, mining and earth moving equipment, industrial equipment and construction are explained and pictured. Also considered are high-temperature properties, heat treatment, corrosion resistance, fabrication, cutting, welding, machining. *U. S. Steel*

1747. Gas Generator
Bulletin G-16A on gas-fired and electric endothermic generators. Specifications. *Ipsen Industries*

1748. Gas-Oil Burner
Bulletin on closed flame gas-oil burners gives operation, capacities, dimensions. *Eclipse Fuel Engineering*

1749. Gear Tester
New bulletins on testing machines for roll testing of spur, worm, spiral and bevel gears. *Geo. Scherr Co.*

1750. Globar Furnaces
Bulletin 153 describes nine types of furnace using silicon carbide heating elements for temperatures to 2600° F. *Hevi Duty*

1751. Gold Plating
Article on analysis of gold and gold alloy plating solutions gives all currently available procedures. *Technic*

1752. Gold Plating
Folder on salts for bright gold plating. Also lists equipment needed. *Sel-Rex*

1753. Graphite Electrodes
16-page book on improved standards of electrode performance shows good and bad practice. *Great Lakes Carbon*

1754. Grinding Wheels
New 28-page condensed catalog on grinding wheel selection. Specifications for many common applications. *Norton*

1755. Handling Devices
Pamphlets on clamps for lifting and handling. Their application to various industries. *Merrill Bros.*

1756. Hardness Numbers
Pocket-size table of Brinell hardness numbers incorporating other tabular information. *Steel City Testing*

1757. Hardness Tester
Bulletin on Impressor portable hardness tester for aluminum, aluminum alloys and soft metals. *Barber-Colman*

1758. Hardness Tester
20-page book on hardness testing by Rockwell method. *Clark Instrument*

1759. Hardness Tester
4-page bulletin on Brinell hardness tester weighing 26 lb. for portable and stationary use. *Andrew King*

1760. Hardness Testers
Catalog of testers for normal hardness, superficial testing, accessory and special testing and micro and macro hardness testing. *Wilson Mechanical Instrument*

1761. Heat Treating
Bulletin 14-T on ovens for heat treatment of aluminum and other low-temperature processing. *Young Bros.*

1762. Heat Treating
Experience at New Bedford Defense Products in projectile heat treating using hardening furnace, quench tank, oil cooler, tempering furnace and cooling chamber. *Sunbeam*

1763. Heat Treating
Catalog N-35 on furnaces for hardening high speed steel. *Sentry Co.*

1764. Heat Treating
56-page "Heat Treating Alloy Steels". *Republic Steel*

1765. Heat Treating
Bulletin describes baskets, crates, trays, furnace parts for heat treating. *Stanwood*

1766. Heat Treating
Data on how to heat, quench, wash and temper automatically. *Metalwash Machinery*

1767. Heat Treating Ammonia
24-page "Guide for Use of Anhydrous Ammonia" describes heat treating and other metallurgical uses. *Nitrogen Div.*

1768. Heat Treating Baskets
12-page bulletin on wire mesh baskets for heat treating and plating. *Wiretex Mfg.*

1769. Heat Treating Compound
Data on dry powder coating for promoting smooth heat treated parts. *Parker Stamp Works*

1770. Heat Treating Equipment
New folder on carburizing boxes, trays, heat treat fixtures and baskets. *Misco*

1771. Heat Treating Fixtures
24-page catalog on heat and corrosion-resistant equipment for heat treating and chemical processing. 30 classifications of equipment. *Pressed Steel*

1772. Heat Treating Fixtures
24-page catalog B-8 on muffles, retorts, baskets, other fixtures for heat treating in gas or salt baths. *Rolock*

1773. Heat Treat Fixtures
New bulletin on trays, boxes and fixtures of nickel chromium alloys for industrial furnaces. *Standard Alloy*

1774. Heat Treating Fixtures
Folder shows 21 examples of heat treating fixtures, trays, baskets, retorts. *Allied Metal Specialties*

1775. Heat Treating Furnaces
New bulletin SC-167 belt-type furnaces. Belts are cast alloys, slat or hinged, mesh, flighted. *Surface Combustion*

1776. Heat Processing
Bulletin answers questions: what is to be heated, what sections are to be heated, why the material is to be treated, to what temperature and for how long. *Selas*

1777. High-Alloy Castings
Bulletin 3150-G on castings for heat, corrosion, abrasion resistance. *Duraloy*

1778. High-Speed Steel
New bulletin on structure and properties of "desegatized" high speed tool steel. *Latrobe*

1779. High-Speed Steels
New bulletin on free machining tool steels and die steels. Descriptions, composition, heat treatment. *Vanadium-Alloys Steel*

1780. High-Temperature Belts
New bulletin on belts of high-temperature alloy for heat treat furnaces. *Electro-Alloys Div.*

1781. High-Temperature Lubrication
Bulletin on colloidal graphite lubrication of kiln cars, oven conveyors and forging dies. *Acheson Colloids*

1782. High-Temperature Steels
87-page book on factors affecting high-temperature properties. 45 pages of data on tensile, creep and rupture properties of 21 high-temperature steels. *U. S. Steel*

1783. High-Vacuum Pumps
Data sheet on physical dimensions, operating data and performance curves for high-vacuum oil diffusion pumps. *Consolidated Vacuum Corp.*

1784. Hydride Descaling
24-page book "Handling Metallic Sodium" with special reference to sodium hydride descaling. *U. S. Ind. Chem.*

1785. Identifying Alloys
Booklet of procedures for rapid identification of more than 125 metals and alloys. *International Nickel*

1786. Impregnating Castings
8-page bulletin on impregnating porous castings. Properties of impregnant. *American Metaseal*

1787. Induction Heaters
New bulletin on low-frequency induction heating describes units for brass, copper, titanium, steel, forgings, light metal extrusion presses. *Magnethermic*

1788. Induction Heating
60-page catalog tells of reduced cost and increased speed of production on hardening, brazing, annealing, forging or melting jobs. *Ohio Crankshaft*

1789. Induction Heating
Bulletin 1440 on system for safety control of induction heating through use of components built into every unit. *Lindberg Engineering*

1790. Induction Heating
36-page catalog on high-frequency induction heating. *Lepel*

1791. Induction Melting
8-page article describes use of induction melting in improved technique for rotor-casting. *Ajax Engineering*

1792. Industrial Fans
Catalogs on various kinds of industrial fans — exhaust, multiblade, backward curve, for high temperatures. *Garden City Fan*

1793. Insulation
40-page industrial products catalog on insulations, refractory products, and others. *Johns-Manville*

1794. Iron Powder
Bulletin on production of iron powder for flame cutting, scarfing, powder metallurgy, electronics and chemical applications. *Easton Metal Powder*

1795. Laboratory Furnaces
Bulletin No. 310 on high temperature electric tube furnaces for laboratories. *Burrell*

1796. Laboratory Furnaces
Data sheets on complete line of laboratory furnaces for metallurgical operations. *Boder Scientific*

1797. Laboratory Ovens
Catalog 331A on new models of laboratory ovens. *Precision Scientific Co.*

1798. Laboratory Supplies
Instruments and apparatus for control, research, development laboratories. *Harshaw Scientific*

1799. Laminated Sheet
12-page bulletin on bonding plastic film and sheeting to metal. *Naugatuck Chemical*

1800. Low-Alloy Steel
60-page book on high-strength low-alloy steel, properties, fabrication and uses. *U. S. Steel*

1801. Low-Carbon Stainless
"Melting Low-Carbon Stainless Steel" shows advantages in use of new low-carbon chromium alloy for producing extra-low-carbon grades. *Electro Metallurgical*

1802. Lubricant
8-page folder describes use of molybdenum disulfide lubricant in cold forming, cold heading and other applications. Case histories. *Alpha Corp.*

1803. Lubricant
Literature on anti-seize molybdenum disulfide lubricant. *Bel-Ray*

1804. Lubrication
Bulletin on FOS process of lubricating steel surfaces for extrusion, drawing, and other metalworking processes. *Pennsylvania Salt*

1805. Machining and Grinding
File on electronic machining and grinding tells how it works, cost for difficult machining jobs, how electrodes are made, how to convert from diamond to electronic grinding. *Elox Corp.*

1806. Machining Titanium
Four discussions of methods, problems, chip formation in grinding and machining titanium. *Cincinnati Milling Machine*

1807. Magnesium
42-page booklet on wrought forms of magnesium. Includes 31 tables. *White Metal Rolling & Stamping*

1808. Magnesium Castings
5-page reprint tells of new developments in making magnesium castings for aircraft needs. *Dow Chemical*

1809. Magnesium Finishing
128-page book describes all methods for finishing magnesium. *Dow Chemical*

1810. Magnetic Alloys
6 pages of data on Curie temperature of many alloys and how this phenomenon is of importance. *International Nickel*

1811. Master Alloys
Bulletin on custom-made alloys for remelt or reprocessing. *Cannon-Muskegon*

1812. Cleaning
New booklet gives case histories of mechanical cleaning with power brushes. *Pittsburgh Plate Glass, Brush Div.*

1813. Melting Furnaces
8-page Bulletin 560 describes stationary and tilting types of two-chamber melting furnaces. Applications to all types of casting. *Lindberg Engineering*

1814. Metal Sorting
Data on nondestructive sorting tool for raw, semi-finished or finished parts. *Dice*

1815. Metallograph
20-page bulletin E-232 on Balphot metallograph with bright field, dark field, polarized light, phase contrast. *Bausch & Lomb*

1816. Microhardness Tester
Bulletin describes the Kentron microhardness tester. *Torsion Balance Co.*

1817. Microscopes
22-page catalog describes microscopes featuring ball bearings and rollers throughout the focusing system and a low-position fine adjustment, providing comfortable operation. *Bausch & Lomb*

1818. Moly-Sulphide Lubricant
40-page booklet on Moly-sulphide lubricant gives case histories for 154 different uses. *Climax Molybdenum*

1819. Mount Press
Bulletin on speed press which features preheated premolds, rapid closing, application to thermo-setting and thermoplastic materials. *Buehler*

1820. Nickel Alloys
40-page book gives corrosion, physical and mechanical properties of Hastelloy alloys; 13 pages of fabrication data. *Haynes Stellite*

1821. Nickel Alloys
38-page handbook on wire, rod, strip of Monel, Inconel, nickel and nickel clad copper. *Alloy Metal Wire Co.*

1822. Nitriding
48-page booklet on nitralloy and nitriding, including the new Floe process. Types of nitriding steels, surfaces not to be hardened, weldability. *Nitralloy Corp.*

1823. Nondestructive Testing
8-page bulletin on equipment for nondestructive testing of bars, rods, tubing. *Magnetic Analysis*

1824. Nonferrous Wire
Folder gives wire gage and footage chart and data on beryllium copper, phosphor bronze, nickel, silver, brass and aluminum wire. *Little Falls Alloys*

1825. Nonflammable Rust Preventive
Bulletin on rust preventive compound which is water soluble, nontoxic and nonflammable. *Production Specialties*

1826. Nuclear Radiation Cell
Data on industrial instrumentation applications of the Ohmart cell, the radioactive sensitive element which converts nuclear radiation into electrical energy. *Minneapolis-Honeywell*

1827. Openhearths
Brochure on modern openhearth design and construction. *Loftus*

1828. Phosphate Coating
24-page booklet describes amorphous phosphate coatings for protection of aluminum alloys and for paint adhesion. *American Chemical Paint Co.*

1829. Pickling Baskets
Data on baskets for degreasing, pickling, anodizing and plating. *Jelliff*

1830. Pickling Baskets
12-page bulletin on mechanical picklers, crates, baskets, chain and accessories. *Youngstown Welding & Eng'g*

1831. Plating Tank Lining
New bulletin on use of Koroseal sheet in plating tanks, racks, vats. Materials that can be handled in Koroseal lined equipment. *Metalweld, Inc.*

1832. Powdered Metals
Bulletin on sintered iron and bronze parts. Sizes, types of parts. *Bassick Co.*

1833. Powdered Metals
Bulletin 800-A on pre-alloyed iron powders with varied chromium-nickel contents. *Metal Hydrides*

1834. Powdered Metals
Booklet tells how things are made of powdered metals, applications and future possibilities. *Stokes*

1835. Precision Casting
New booklet on pressure castings made by frozen mercury method. *Mercast Corp.*

1836. Precision Casting
8-page bulletin on investment castings of various ferrous and nonferrous alloys. *Engineered Precision Casting*
(*Continued on p. 36-A*)

(Continued from page 35)

1837. Precision Casting
44-page Catalog 53 covers every stage of the investment casting process. *Alexander Saunders*

1838. Precision Casting
12-page book on alloy selection and design for precision casting. *Arwood Precision Casting Corp.*

1839. Presses
12-page booklet 203 on hydraulic presses for forming and drawing. Puncher, shears, benders, straighteners. *Williams-White & Co.*

1840. Pyrometer Accessories
Bulletin 4181 on specifications and performance data for thermocouples. Thermocouple alloys, temperature-millivolt relationship curves, temperature conversion table. *Illinois Testing Laboratories*

1841. Pyrometer Calibration
"Pyrometer Thermocouple Calibration Data" includes tables of data released by National Bureau of Standards. *Bristol Co.*

1842. Pyrometers
52-page book on optical, radiation and photoelectric pyrometers. Accessories, special features, operation. *Anglo-American Scientific*

1843. Pyrometers
12-page Bulletin 713 on indicating and controlling pyrometers. Functional diagrams of installations. *General Electric*

1844. Quench Agitation
Information on mixers and agitators, including units applicable to industrial quenching equipment. *Mixing Equipment*

1845. Quenching Oil
8-page booklet on applications and cost reductions in oil-quenching installations. *Sun Oil*

1846. Quenching Oil
Technical bulletin on quenching oil and accelerators to provide deeper hardening. *Park Chemical*

1847. Radiation Equipment
56-page catalog on equipment used in X-ray and radiation fields describes new cobalt 60 unit. *Bar-Ray*

1848. Radiation Protection
12-page booklet on films for determining amount of radiation. Used in research laboratories, nondestructive testing laboratories. *Du Pont*

1849. Radiography
16-page bulletin on materials and accessories for radiography. Density curves for four types of films. *X-Ray Div., Eastman Kodak*

1850. Radiography
Bulletin JR and AR on one and two million volt X-ray generator. *High Voltage Engineering Corp.*

1851. Rare Earths
8-page Progress Report Number 1, "Rare Earths in Iron and Steel Melting". *Molybdenum Corp.*

1852. Refractory Cement
Bulletin discusses refractories and heat-resistant concrete. *Lumnite Div.*

1853. Roll Formed Shapes
24-page Bulletin 1053 on designing, forming and producing shapes from ferrous and nonferrous metals. *Roll Formed Products Co.*

1854. Rust Preventive
Pamphlet on Oilcoat T for prevention of rust in lubricating systems. *Gulf Oil*

1855. Rustproofing
New bulletin on rust inhibiting primer. *Rusticide Products Co.*

1856. Salt Bath Furnaces
Data on salt bath furnaces for batch and conveyorized work. *Upton*

1857. Salt Baths
32-page booklet on heat treating in liquid salt baths. Properties of several liquid baths. *E. F. Houghton*

1858. Sand Control
32-page book on defects and troubles in foundry and how to remedy through sand control. *Claud S. Gordon Co.*

1859. Shearing
16-page catalog on pivoted-blade shears for cutting metal up to 1.25 in. thick. *Cleveland Crane & Engineering*

1860. Shot Peening
16-page booklet on selection and use of shot and grit for peening. *Cleveland Metal Abrasive*

1861. Silver Brazing
10-page technical bulletin on brazing preforms. Specifications for 13 types of joints. *Lucas-Milhaupt*

1862. Specification Key
Guide to Government specifications for phosphatizing, rustproofing and paint bonding chemicals. *American Chemical Paint*

1863. Spectrometry
12-page brochure on quality control with a direct reading spectrometer. *Baird Assoc.*

1864. Spot Welding
Bulletin on inert gas-shielded spot welding gun which welds from one side only and without a back-up plate. *Air Reduction*

1865. Spray Washers
New 16-page bulletin 301 on many types of power spray washers and their layouts and applications. *Peters-Dalton*

1866. Spring Steels
Spring steel catalog offers 785 sizes of hardened and tempered spring steels, and 133 cold rolled and bright annealed sizes in stock. *Sandvik Steel*

1867. Stainless Castings
8-page bulletin gives recommendation charts for type of stainless to use in various corrosive solutions, under various conditions. *Waukesha Foundry*

1868. Stainless Castings
Bulletin on advantages of corrosion-resistant castings. *Ohio Steel Foundry*

1869. Stainless Electrodes
New 16-page data bulletin on selection of proper grades of welding rod for each grade of stainless steel. *Crucible Steel*

1870. Stainless Fasteners
7-page report on physical characteristics and uses of stainless fasteners. *American Screw Company*

1871. Stainless Fastenings
20-page catalog of stainless steel cap screws, nuts, washers, machine screws, sheet metal screws, set screws, pipe fittings and specialties. *Star Stainless Screw*

1872. Stainless Steel
44-page book gives detailed information on use of stainless steel in the chemical industries. *Crucible Steel*

1873. Stampings
Data on how stamped assemblies save time and money. *J. H. Sessions*

1874. Steel 52100
New stock list on 52100 tubing, bars, and ring forgings. *Peterson Steels*

1875. Steel Melting
Bulletin 11-C on high-frequency induction furnaces for steel and ferrous alloys. *Ajax Electrothermic*

1876. Steel
16-page booklet lists and describes ma-

FIRST CLASS
PERMIT No. 1595
(Sec. 34.9 P.L. & R.)
Cleveland, Ohio

BUSINESS REPLY CARD
No Postage Stamp Necessary If Mailed In the United States

4c POSTAGE WILL BE PAID BY—

METAL PROGRESS
7301 Euclid Avenue
CLEVELAND 3, OHIO

jor stainless, tool and electrical steels. *Allegheny Ludlum*

1877. Steel
Folder gives advantages of leaded alloys. Case histories. *A. M. Castle*

1878. Steel
Bulletin on nickel-copper steel of low-alloy, high-strength type. *Youngstown Sheet and Tube*

1879. Strip Calculator
Stainless steel strip calculator is a slide rule designed to determine weight of coil. *Ulbrich Stainless Steels*

1880. Subzero Freezer
8-page folder on portable freezer, 110-volt a.c., operating to −180° F., for shrink fitting, hardening, stabilizing and testing. *Webber Mfg.*

1881. Tellurium Copper
6-page pamphlet on properties of 0.5% tellurium copper alloy. *Chase Brass*

1882. Temperature Measurement
70-page book on thermo-electric pyrometers, accessories, indicating instruments, potentiometers. *Anglo-American Scientific*

1883. Tempering
20-page bulletin on Homo heat treating equipment and results. *Leeds & Northrup*

1884. Testing
4-page bulletin No. 4211 on Sonntag impact machines. *Baldwin-Lima-Hamilton*

1885. Textured Metal
16-page booklet on advantages and applications of textured metal. *Rigidized Metals*

1886. Thermocouple Data
42-page Bulletin TC-9 on thermocouples, radiation detectors, resistance bulbs, accessories. *Wheelco*

1887. Titanium Alloy
Data on ternary alloy with 3% aluminum and 5% chromium gives physical properties, forging temperatures, high temperature characteristics. *Mallory-Sharon Titanium*

1888. Tool and Die Steels
26-page book on six oil and air hardening steels for high-production tools and dies. Many uses illustrated. *Bethlehem Steel*

1889. Tool Steel
Bulletin on precision-ground oil-hardening and air-hardening tool steel flat stock. *Jessop*

1890. Tool Steel Heat Treat
Bulletin 1147EE on electric furnace for heat treatment of high speed tool steel. *Hevi Duty*

1891. Tool Steel Selector
Twist the dial of the 9-in. circular selector and read off the tool steel for your application. *Crucible Steel*

1892. Tube Mills
Brochure illustrates and describes complete seamless tube mills for varied requirements. *Mannesmann-Meer*

1893. Torsion Tester
Bulletin RT-10-54 on new 60,000 in.-lb. precision torsion tester. *Riehle*

1894. Tubing
52-page "Handbook of Seamless Steel Tubing". 26 pages of data. *Timken*

1895. Tukon Tester
12-page bulletin DH-114 on Tukon micro and macro hardness testers. *Wilson Mech. Inst.*

1896. Tungsten
New 20-page bulletin on manufacture, properties and uses of tungsten. Flow chart of tungsten production. *Sylvania Electric Products*

1897. Ultra Strength Steel
Results of three-year research and test program evaluating properties of Type 4340 steel for aircraft structures. *International Nickel*

1898. Ultrasonic Cleaning
Folder on Sonogen ultrasonic generator for metal cleaning. *Branson*

1899. Vacuum Gages
32-page Catalog 7001 on gages for vacuums to 10^{-11} mm. Hg and pressures to 150,000 psi. *Minneapolis-Honeywell*

1900. Vacuum Metallurgy
Articles on commercial vacuum furnaces for metals and alloys and some aspects of vacuum melted metals. *National Research Corp.*

1901. Vacuum Pumps
24-page Bulletin V51 on high-vacuum pumps and accessories. *Kinney Mfg.*

1902. Valves
New 16-page catalog on two types of goggle valves for blast furnace and coke oven gas mains. *Salem-Brosius*

1903. Vanadium Products
12-page brochure on 25 steel, iron, aluminum and chemical products. Composition and applications. *Vanadium Corp.*

1904. Vapor Absorber
Bulletin on Vape-Sorber for continuous removal of petroleum vapor, dirt and liquids from compressed air and other gases. *Selas*

1905. Vibration Meter
New bulletin on equipment and accessories for measuring vibration. *Consolidated Engineering*

1906. Welding Equipment
Catalog on Cadweld process and arc-welding accessories. *Erico Products*

1907. Welding Stainless
54-page manual on welding processes for stainless, with recommendations and settings for arc, spot and pulsation welding. Soldering and brazing. *Republic Steel*

1908. Wire
Bulletin on extruded, Wollaston, Taylor Process and resistance wires of low fusing and precious metals. *Baker & Co.*

1909. Wire Cloth
84-page booklet on applications, meshes, baskets, filters. *Cambridge Wire Cloth*

1910. Wire Straightening
Bulletin 52-C describes precision machine for straightening small wire with extreme accuracy. Applies to round wire 0.007 to 0.125 in. diameter of ferrous or nonferrous metal. *Medart Co.*

1911. Wire-Wrap Joining
New bulletin on wire-wrap method of making solderless electrical connections. *Keller Tool Co.*

1912. X-Ray Inspection
248-page catalog and supplement on materials used in X-ray inspection. *Picker X-Ray*

1913. X-Ray Supplies
50-page catalog of industrial X-ray supplies and accessories. *Westinghouse*

1914. Zinc Die Casting
New 24-page booklet on zinc for die castings and applications of die castings. *St. Joseph Lead Co.*

1915. Zirconia
Folder on new, patented process in which each zirconia crystal is stabilized. Characteristics of stabilized zirconia. *Zirconium Corp. of America*

November, 1954

1615	1639	1663	1687	1711	1735	1759	1783	1807	1831	1855	1879	1903
1616	1640	1664	1688	1712	1736	1760	1784	1808	1832	1856	1880	1904
1617	1641	1665	1689	1713	1737	1761	1785	1809	1833	1857	1881	1905
1618	1642	1666	1690	1714	1738	1762	1786	1810	1834	1858	1882	1906
1619	1643	1667	1691	1715	1739	1763	1787	1811	1835	1859	1883	1907
1620	1644	1668	1692	1716	1740	1764	1788	1812	1836	1860	1884	1908
1621	1645	1669	1693	1717	1741	1765	1789	1813	1837	1861	1885	1909
1622	1646	1670	1694	1718	1742	1766	1790	1814	1838	1862	1886	1910
1623	1647	1671	1695	1719	1743	1767	1791	1815	1839	1863	1887	1911
1624	1648	1672	1696	1720	1744	1768	1792	1816	1840	1864	1888	1912
1625	1649	1673	1697	1721	1745	1769	1793	1817	1841	1865	1889	1913
1626	1650	1674	1698	1722	1746	1770	1794	1818	1842	1866	1890	1914
1627	1651	1675	1699	1723	1747	1771	1795	1819	1843	1867	1891	1915
1628	1652	1676	1700	1724	1748	1772	1796	1820	1844	1868	1892	
1629	1653	1677	1701	1725	1749	1773	1797	1821	1845	1869	1893	
1630	1654	1678	1702	1726	1750	1774	1798	1822	1846	1870	1894	
1631	1655	1679	1703	1727	1751	1775	1799	1823	1847	1871	1895	
1632	1656	1680	1704	1728	1752	1776	1800	1824	1848	1872	1896	
1633	1657	1681	1705	1729	1753	1777	1801	1825	1849	1873	1897	
1634	1658	1682	1706	1730	1754	1778	1802	1826	1850	1874	1898	
1635	1659	1683	1707	1731	1755	1779	1803	1827	1851	1875	1899	
1636	1660	1684	1708	1732	1756	1780	1804	1828	1852	1876	1900	
1637	1661	1685	1709	1733	1757	1781	1805	1829	1853	1877	1901	
1638	1662	1686	1710	1734	1758	1782	1806	1830	1854	1878	1902	

METAL PROGRESS,

7301 Euclid Avenue, Cleveland 3, Ohio

Please have literature circled at the left sent to me.

Name ____________________

Title ____________________

Company ____________________

Address ____________________

City and State ____________________

Postcard must be mailed prior to Feb. 1, 1955
Students should write direct to manufacturers.

IT'S MADE OF "BERYLCO" BERYLLIUM COPPER

Intermittent air conditioning, railroads find, is worse than none. They solve that problem by connecting conditioned cars to stand-by power when the train is not running. The chances are that the connectors used will be those made by Joy Manufacturing Co., which feature replaceable female contacts made of "Berylco" beryllium copper.

Electrical conductivity, of course, is a must in any contact, but even more important here is the elasticity and wear resistance required. For this combination of qualities, "Berylco" can't be beat. It will take repeated abuse without appreciable wear. It has plenty of "bounce" to resist taking a permanent set or to relax after many, many rough connect and disconnect operations. It doesn't lose its bulldog grip under the jockeying railroad cars are subject to.

If you are looking for an engineering material which will do more than one job well, you ought to investigate the advantages of "Berylco" beryllium copper. No other alloy combines such properties as strength, hardness, conductivity, fatigue resistance, corrosion resistance, elasticity and formability.

For engineering help or sample material, write any of the offices listed below.

ALL THE FACTS

This 20-page booklet lists available beryllium copper forms and materials, offers you the most complete selection in the industry. Send for your free copy today.

TOMORROW'S PRODUCTS ARE PLANNED TODAY . . . WITH "BERYLCO" BERYLLIUM COPPER

BERYLCO®

THE BERYLLIUM CORPORATION

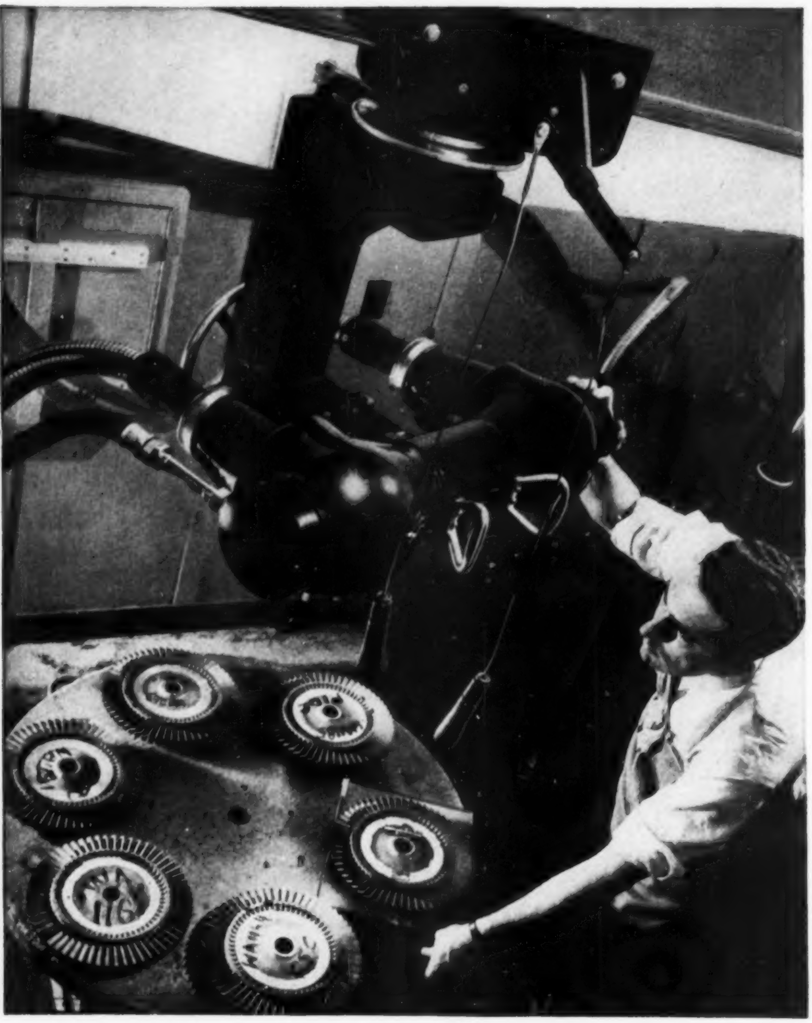
DEPT. 4L, READING 9, PENNSYLVANIA

New York • Springfield, Mass. • Rochester, N.Y. • Philadelphia • Cleveland • Dayton • Detroit • Pittsburgh • Chicago • Minneapolis • San Francisco • Los Angeles

Representatives in principal world-trade centers

Full X•Ray Flexibility

assured for all-purpose inspection



Westinghouse 250 KV JIB CRANE X-RAY UNIT

Curtiss-Wright uses Westinghouse X-ray equipment for non-destructive testing of the important parts of their outstanding aircraft engines. The application pictured here shows the 250 KV X-ray tubehead, mounted on the jib crane tubestand, being positioned for the examination of the critical welds on gas turbine booster rotors.

The keynote for the selection of this equipment was *flexibility*—since *flexibility* results in more radiographs per shift.

1 Since the kilovoltage can be varied from 30-250 KV with greater X-ray output per KV resulting from the constant potential high voltage supply, the unit can be used to inspect materials from under $\frac{1}{8}$" aluminum to 4" of steel.

2 The jib crane tubestand carries the tubehead from less than 3' up to 9' above the floor and from 50" to $14\frac{1}{2}$' from the center of the vertical column which, in turn, can be rotated 135° in each direction. The tubehead mounting permits rotation of 180°, in either direction, around a vertical axis, and 140° around the long axis of the tubehead. The X-ray tube can be positioned easily and quickly to radiograph parts ranging in size from very small to very large.

Call your Westinghouse representative, or write to Westinghouse Electric Corporation, Industrial X-ray Section, 2519 Wilkens Avenue, Baltimore 3, Maryland.

J-08263B

X-RAY DIVISION • WESTINGHOUSE ELECTRIC CORPORATION • BALTIMORE 3, MARYLAND

FLUOREX
PORTABLE UNITS
X-ACTRON
JIB CRANE
PRODUCTOGRAPH
MOBILE UNITS
GRAIN INSPECTION UNIT
SERVICE
ACCESSORIES

YOU CAN BE SURE...IF IT'S

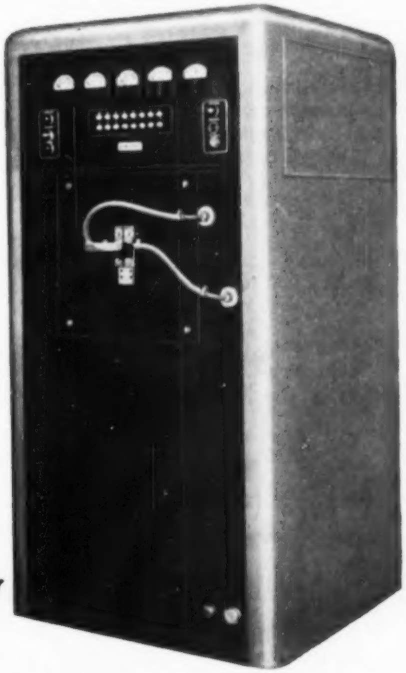
Westinghouse

To help improve induction heating applications, Lindberg engineers have spent two years developing equipment for M-G set frequencies of 1 kc., 3 kc. and 10 kc. This equipment is now available to you.

This development has also produced many advanced design features that are incorporated in control and heating stations used in connection with motor generator equipment.

Generators are available in power outputs from 30 kw. to 1250 kw.

Lindberg engineers are now equipped to solve your metal heating problems using optimum frequencies for specific applications from 60 cycles upwards. For information consult your nearest Lindberg field office or write for Bulletin No. 1460.



The High Frequency Division of Lindberg Engineering Company announces a complete line of MOTOR GENERATOR EQUIPMENT for all Induction Heating Applications

HIGH FREQUENCY DIVISION
Lindberg Engineering Company
2448 W. Hubbard St., Chicago 12, Illinois

How to get the one tube steel that's best for your job: *Ask the experts!*

This month's report is on: **SICROMO 2**

Has outstanding surface and structural stability at 1200° F. Has better oxidation and corrosion resistance than 2% Cr.-Mo steel. Recommended for service up to 1200° F. as tubes in cracking coils, reforming units, heat exchangers, vapor line and hot oil piping. Also as return-bend forgings for oil heaters.

ONE OF 24 TIMKEN HIGH TEMPERATURE STEELS

Carbon	Sicromo 2	Sicromo 5S	18-8Ti
Carbon-Mo.	Sicromo 2½	Sicromo 5MS	16-13-3
DM-2	2¼% Cr.-1% Mo.	Sicromo 7	25-20*
Silmo	Sicromo 3	Sicromo 9M	25-12*
DM	4-6% Cr.-Mo.	18-8 Stainless	35-15**
2% Cr.-Mo.	4-6% Cr.-Mo.-Ti.	18-8 Cb	16-25-6**

** Available as seamless tubing on an experimental basis only.*
***Not available as seamless tubing.*

YOU can probably find several high temperature tube steels that will solve your heat, pressure, corrosion and oxidation problems. But only one steel will give you maximum tube life per dollar.

To get the one high temperature tube steel that's best for your job, ask the metallurgists of the Timken Company. They *are* the experts!

With more than 20 years of steel research and experience, Timken Company metallurgists are recognized authorities on high temperature steels. They'll put this experience at your disposal. Help you select from 24 different analyses the one tube steel that will give you the best life/cost ratio. And regardless of which analysis you select, you'll be assured of uniform quality. The Timken Company rigidly controls quality from melt shop through final inspection.

Let the Timken Company help you with your tube problems. *Ask the experts!* The Timken Roller Bearing Company, Steel and Tube Division, Canton 6, Ohio. Cable address: "TIMROSCO".

Chlorination apparatus purifies extracted non-metallic residues to determine steel cleanliness. Research like this helps assure the Timken Company's leadership in high temperature steels.

YEARS AHEAD—THROUGH EXPERIENCE AND RESEARCH

SPECIALISTS IN FINE ALLOY STEELS, GRAPHITIC TOOL STEELS AND SEAMLESS TUBING

Eclipse FUEL ENGINEERING COMPANY

Recommends

TASIL

BURNER BLOCKS

Eclipse Fuel Engineering Co., Rockford, Ill., for 25 years has been regularly supplying Taylor Sillimanite (TASIL) pre-fired burner blocks on their Eclipse Blast-type Entrainment Burners for severe and high-temperature service in heating, forging, and metal-melting furnaces. TASIL is specified because these refractory blocks must give extended life and hold original dimensions without shrinking deforming, cracking or spalling.

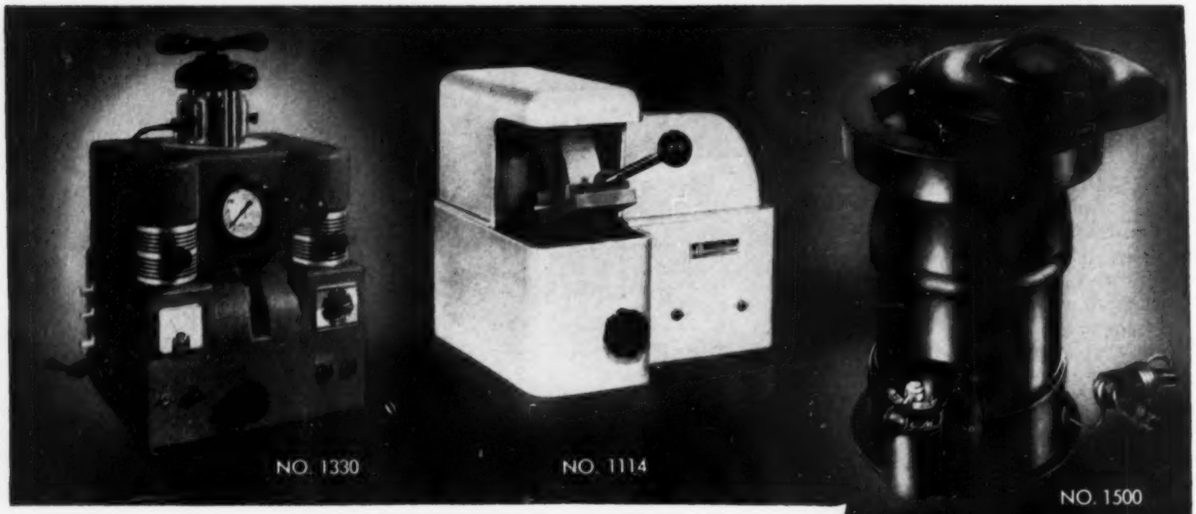
TAMUL, the sintered synthetic mullite refractory, is also coming into wide use for high temperature applications. Like TASIL it has a softening point several hundred degrees above that of the best grades of fireclay, super-duty or silica brick; is unaffected by oxidizing or reducing atmospheres and is volume stable at operating temperatures of most industrial furnaces.

For longer service from your heating and heat-treating furnaces, specify TASIL or TAMUL burner blocks.

Exclusive Agents in Canada:
REFRACTORIES ENGINEERING AND SUPPLIES, LTD.
Hamilton and Montreal

TAYLOR ZIRCON — TAYLOR SILLIMANITE

The CHAS. TAYLOR SONS Co.
A SUBSIDIARY OF NATIONAL LEAD COMPANY
REFRACTORIES SINCE 1864 • CINCINNATI • OHIO • U.S.A.



NO. 1700

For Heating with "Radiant Tubes"

LEE WILSON Engineering Company, Inc.

uses.

SPENCER HARTFORD turbos

The Lee Wilson "O" Tube method of single stack heat treating is well known. The illustration shows a unit on test with a Spencer Turbo for the air pressure.

In one compact unit, the Spencer Turbo combines simplicity with unusual reliability, and provides a steady flow of clean air with a constant pressure.

Power varies with the load and efficiencies are high at all loads, resulting in extremely high over all efficiencies under fluctuating service demands.

Maintenance records show that batteries of Spencers operate for years at a cost of one dollar per machine per year for repair parts. Many of the Spencers built a quarter of a century ago are giving satisfactory service today maintaining their original test efficiencies.

Special Spencer Bulletins are available as follows: Data, No. 107, Gas Boosters, No. 109, Four Bearing, No. 110, Blast Gates, No. 122, Foundries, No. 112 and the General Bulletin is No. 126.

THE SPENCER TURBINE COMPANY

SPENCER
HARTFORD

HARTFORD 6
CONNECTICUT

494-C

Manufacturers of Turbo-Compressors and Heavy Duty Vacuum Cleaners

IT TAKES MORE THAN THESE

...to build a bridge

IT TAKES MORE THAN THESE

...to heat treat metals

BOTH MUST HAVE THE VITAL INGREDIENTS — SKILL AND EXPERIENCE

It is a sad fact that many skilled production men and managers have been, in recent years, badly misled into believing that given a furnace — a quench tank — a salt bath, and a corner of floor space — they can promptly and easily fulfill their heat treating requirements. Aggressive and misleading selling by some furnace and equipment manufacturers (fortunately only a small minority) has encouraged this misconception that equipment and materials alone are the essential factors in heat treating operations.

The cold fact is, that without the proper combination of human operational skill and technical knowledge developed over **years** of practical experience, even the best, most mechanical, most modern heat treating equipment becomes a potent menace to your product and your profit margin.

Careful evaluation of **all** the factors involved in any heat treating operation — large or small — always reveals that TECHNICAL SKILL BORN OF EXPERIENCE tops the list.

Make it head **your** list when you are analyzing the pros and cons of the question "Shall we do our own heat treating?" Write for a useful folder — "Facts and Figures on Heat Treating Costs".

THERE'S A HEAT TREATING SPECIALIST NEAR YOUR PLANT

METAL TREATING INSTITUTE

Ace Heat Treating Company
Elizabeth, New Jersey

Anderson Steel Treating Co.
Detroit, Michigan

Benedict-Miller, Inc.
Lyndhurst, New Jersey

Bennett Heat Treating Co., Inc.
Newark 5, New Jersey

Commercial Metal Treating, Inc.
Bridgeport, Connecticut

Commercial Steel Treating Corp.
Detroit 4, Michigan

Cook Heat Treating Co. of Texas
Houston 11, Texas

The Dayton Forging & Heat Treating Co.
Dayton 3, Ohio

Dexter Metal Treating Co.
Oakland 21, California

Drever Company
Philadelphia 33, Pennsylvania

Greenman Steel Treating Company
Worcester 5, Massachusetts

Fred Heinzelman & Sons
New York 12, New York

Alfred Heller Heat Treating Co.
New York 7, New York

Hollywood Heat Treating Co.
Los Angeles 38, California

L-R Heat Treating Company
Newark, New Jersey

The Lakeside Steel Improvement Co.
Cleveland 14, Ohio

Metallurgical, Inc.
Minneapolis 7, Minnesota

Metallurgical, Inc.
Kansas City 8, Missouri

Metlab Company
Philadelphia 18, Pennsylvania

Metro Heat Treating Corp.
New York 13, New York & Ridgefield, N.J.

O. T. Muehlemeyer Heat Treating Co.
Rockford, Illinois

New England Metallurgical Corp.
South Boston 27, Massachusetts

Paulo Products Company
Saint Louis 10, Missouri

Pittsburgh Commercial Heat Treating Co.
Pittsburgh 1, Pennsylvania

The Queen City Steel Treating Co.
Cincinnati 25, Ohio

J. W. Rex Company
Lansdale, Pennsylvania

Stanley P. Rockwell Company
Hartford 5, Connecticut

Temperature Processing Co., Inc.
North Arlington, New Jersey

C. U. Scott & Son, Inc.
(Stainless Steels)
Rock Island, Illinois

Syracuse Heat Treating Corp.
Syracuse, New York

Temperature Processing Company, Inc.
North Arlington, New Jersey

Winton Heat Treating Company
Cleveland 16, Ohio

Metal Progress

BULLETIN BOARD

THE BUYERS GUIDE FOR METALS ENGINEERS

MERIAM

MANOMETERS

U-TYPE • WELL TYPE • DUAL TUBE

FLOW METERS

DRAFT GAUGES

For measuring pressure, vacuum and differential pressure of liquids and gases. Also a complete line of accessories.

ASK FOR CATALOG C-12

THE MERIAM INSTRUMENT CO.
10932 MADISON AVE.
CLEVELAND 2, OHIO

U-TYPE MANOMETER

LIST NO. 48 ON INFO-COUPON PAGE 64

If you want to perform
Tensile or Brinell testing operations
quickly and simply—*contact*

Detroit Testing Machine Company
9390 Grinnell Ave. • Detroit 13, Mich.

LIST NO. 54 ON INFO-COUPON PAGE 64

KENTRON

MICRO HARDNESS TESTER

KNOOP

VICKERS

Applies 1 to 10,000 gram loads

Write for Bulletin

Kent Cliff Laboratories Div.

The Torsion Balance Company

CLIFTON NEW JERSEY

LIST NO. 53 ON INFO-COUPON PAGE 64

ALL TYPES OF
LABORATORY
FURNACES
BY
Boder

LIST NO. 55 ON INFO-COUPON PAGE 64

LAB-HYAM

Protective Atmosphere H_2N_2
Less Expensive-More Convenient
LAB size for LAB work

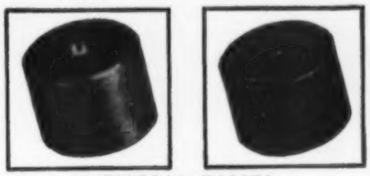
Protected bright annealing is now here for test and pilot runs of electric metals, stainless steels, copper or silver brazing; for sintering or reducing powder metals and for bright tempering of any ferrous or non-ferrous metal or alloy. How about atmosphere?

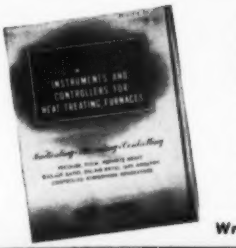
At 1900°F. from raw ammonia gas LAB-HYAM catalyst chamber produces a 75% hydrogen—25% nitrogen mixture from 99.9% dissociated ammonia, delivering protective atmosphere at 5 to 35 C.F.H. through needle valve.

Ask for Bulletin L-H for more information regarding this new laboratory size Dissociated Ammonia Generator.

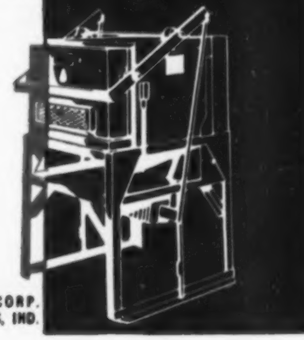
LAB-HYAM H_2N_2 GENERATOR

BODER SCIENTIFIC COMPANY
719 LIBERTY AVE., PITTSBURGH 22, PA.
PHONE: ATLANTIC 1-5525





INSTRUMENTS AND CONTROLLERS FOR HEAT TREATING FURNACES



HERE'S HELP

for your engineer-recruitment problem

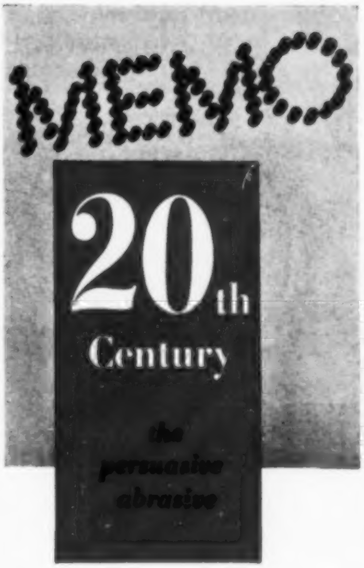
Engineers' Joint Council and The Advertising Council offer free, expert help to advertisers promoting engineering as a career.

A booklet has been prepared by The Advertising Council in cooperation with the Engineers' Joint Council to help you in recruiting engineers for the future.

1. It tells you what the problem is and the important part you can play in solving it.
2. It outlines the advantages of an engineering career to help your company develop advertising appeals.
3. It informs you as to the current activities of industry in the education and recruitment of engineers.
4. It offers specific suggestions as to what you can do (from present manpower).
5. It provides material that you can use in your own local and national programs.

Many companies are using this booklet today. They say that it helps in orienting their engineer-recruitment advertising to industry-wide recruitment programs. Send for the booklet now. Address: The Advertising Council, Inc., 25 West 45th St., New York 36, N.Y.

This space contributed by American Society for Metals



Make a mental note to specify 20th Century *Normalized shot or grit for your abrasive requirements. It's manufactured under close laboratory control to assure consistent high quality, greater uniformity, longer wear, and maximum production efficiency and economy.

Write for new catalog No. 1153.

THE CLEVELAND Metal Abrasive CO.

836 East 67th Street • Cleveland 8, Ohio
Howell Works: Howell, Michigan

*One of the world's largest producers of quality shot, grit and powder — Hard Iron — Malleable (*Normalized) — Cut Wire — Cast Steel (Realsteel)*

*Copyrighted trade name

LIST NO. 2 ON INFO-COUPON PAGE 64

Prove it!

Prove to your own satisfaction that the MOLYKOTE line of industrial lubricants is one of the most spectacular contributions to metal progress in many decades. Send for free literature today . . . and then order a trial supply.

MOLYKOTE®

INDUSTRY'S MOST VERSATILE LUBRICANT

The tremendous lubricity of MOLYKOTE depends on the unique molecular structure of the compound. Read the story behind its development and the jobs it can do better than any other lubricants.

Send for free catalog today!

THE ALPHA CORPORATION

LIST NO. 110 ON INFO-COUPON PAGE 64

WELDCO

FABRICATED MONEL PICKLING EQUIPMENT

- Hairpin Hooks • Sheet Crates
- Steam Jets • Chain
- Mechanical Bar, Tube and Coil Picklers

THE YOUNGSTOWN WELDING & ENGINEERING CO.

3721 OAKWOOD AVE. YOUNGSTOWN, OHIO

LIST NO. 94 ON INFO-COUPON PAGE 64

BASKETS

for all industrial requirements

for de-greasing — pickling
anodizing — plating
materials handling
small-parts storage
of any size and shape —
any ductile metal

by

WIRE PRODUCTS
Jelliff
SINCE – 1880

THE C. O.
JELLIFF MFG. CORP.
28 Pequot Road
Southport, Conn.

LIST NO. 91 ON INFO-COUPON PAGE 64

RUST-LICK
IN
AQUEOUS SYSTEMS

Grade "B"
FERROUS METAL PROCESSING
Eliminates . . .
Rust
Fire Hazards
Toxicity
Dermatitis
Degreasing

Write for free sample and brochure
Specify Grade "B"

PRODUCTION SPECIALTIES, INC.
755 BOYLSTON STREET
BOSTON 16, MASS.

LIST NO. 105 ON INFO-COUPON PAGE 64

INDUSTRIAL ELECTROPLATED GOLD now answers production needs in many fields, aside from obvious applications in instrument-making and electronics. Unusual properties of electroplated gold — physical, thermal, chemical, electrical, optical and corrosion resistant as well as decorative—enable it to solve an amazing range of hitherto insoluble problems. Names of major industrialists taking advantage of new developments in gold electroplating are available from Technic, Inc. — originator of methods of electroplating gold *with scientific accuracy*. While this company does not process or finish metals, it does equip its patrons to perform these operations efficiently and economically — achieving unprecedented accuracy in control of quality, evenness, thickness, color, and hardness of gold deposits. Manufacturers who have not yet explored the high production values of electroplated gold are invited to send specific problems to find out exactly what benefits they can expect. Also available: "Electroplated Gold" data sheet. Address TECHNIC, INC., 39 H Snow Street, Providence, R. I.

Advertisement Advertisement Advertisement

LIST NO. 116 ON INFO-COUPON PAGE 64

ask **SESSIONS**
HOW
STAMPED ASSEMBLIES
SAVE TIME & MONEY

Send samples or prints for quotations on special stampings and sub-assemblies.

J. H. SESSIONS & SON

291 RIVERSIDE AVENUE • BRISTOL, CONN.

LIST NO. 119 ON INFO-COUPON PAGE 64

HOW TO DO BRIGHT GOLD PLATING *without scratch brushing or buffing!*

GOLD
SILVER
RHODIUM

Sel-Rex

BRIGHT GOLD PROCESS

FOR INDUSTRIAL and DECORATIVE USES

1. Exceptionally hard deposits — twice the hardness of conventional gold plating.
2. Operates at room temperature — requires absolute minimum control.
3. Excellent metal distribution and "throwing power."

SEL-REX PRECIOUS METALS, INC.
Dept. BB, 229 Main Street
Belleville 9, N. J.

LIST NO. 108 ON INFO-COUPON PAGE 64

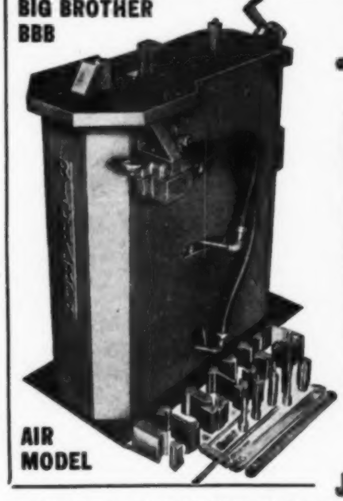
"Pur-Blac"

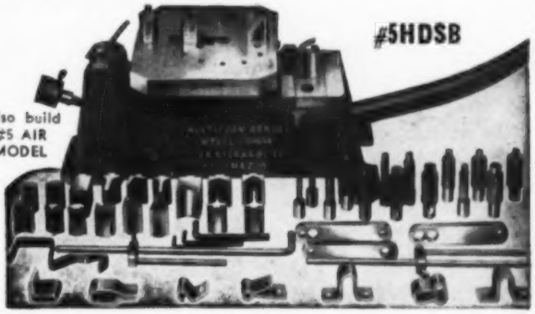
- Economical
- No Change in Dimension
- Corrosion Resistant
- Perfect Uniformity
- Non-Technical

The Black Oxide Finish That Penetrates Iron & Steel Surfaces

PURITAN MANUFACTURING CO.
WATERBURY, CONN.

LIST NO. 95 ON INFO-COUPON PAGE 64





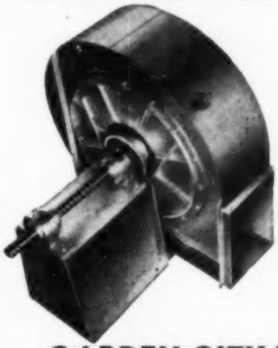
Plan to Attend the

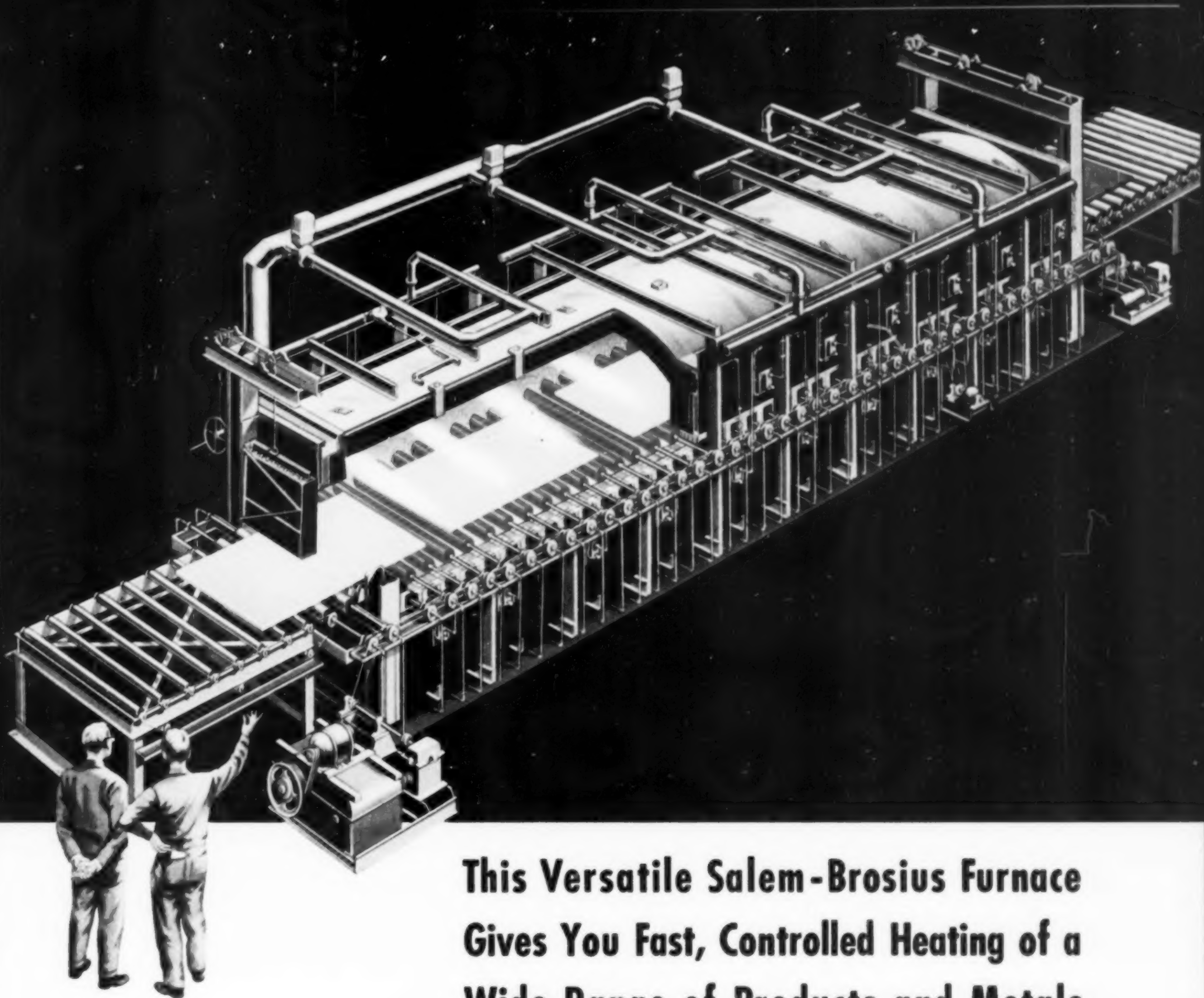
WESTERN METAL SHOW

Los Angeles

March 28 to April 1

1955





This Versatile Salem-Brosius Furnace Gives You Fast, Controlled Heating of a Wide Range of Products and Metals

This roller hearth furnace, designed by Salem-Brosius, gives you fast, automatic control of heating for a variety of shapes and types of metals.

High temperature non-ferrous alloys, steel, brass and aluminum in slabs, sheets, packs, flat bars—even trays of small parts—are heated in this type furnace. This installation heats high temperature alloy sheets to 2250°F at rates up to 7500 pounds per hour. Typical sizes of slabs and packs heated in this 38-foot furnace will range from 40 x 71 inches to 58 x 95 inches.

Heating is precisely controlled to within extremely narrow limits through three zones by automatic indicating-recording pyrometers and thermocouples.

The material moves through the furnace on a roller hearth which consists of a series of Hastelloy water-cooled rolls. This furnace has operated for more than 3800 hrs. without roll replacement—an outstanding achievement for such furnaces. Sound design and top-quality materials and components, such as efficient burners and devices for close control of operating temperatures are your assurance of long, trouble-free, economical operation.

As a leader in the field of designing, fabricating and installing precise heating and heat-treating furnaces, Salem-Brosius recently augmented its technical skills by the acquisition of the George J. Hagan Company—now offers you the combined special talents of both organizations in solving your heating problems. To learn how you may improve your heating practice, and increase production with economy, ask to have an engineer call. He will be glad to study your problem and submit a recommendation.

SALEM-BROSIUS, INC.

EXECUTIVE OFFICES: 248 FOURTH AVENUE, PITTSBURGH 22, PA.

THIS IS THE ACCOLOY TRADEMARK

You've heard of it . . .

You've seen it . . .

***Now* try it!**

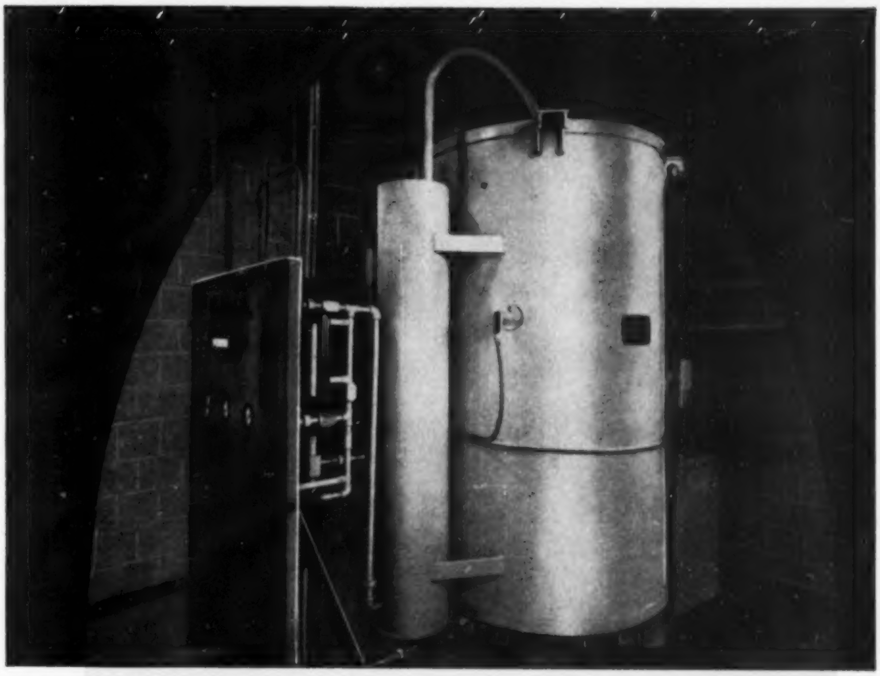
HEAT RESISTANT CASTINGS

ACCOLOY

STAINLESS STEEL CASTINGS

and see for yourself why these
Heat and Corrosion Resistant Castings
made by ACCOLOY are "preferred by industry"

ALLOY ENGINEERING & CASTING CO. **CHAMPAIGN • ILLINOIS**




Clean sheets...

Typical gear and spline processed by Wright Aeronautical Corp.

how much can you cut your finishing costs

with NITRALLOY® and FLOE PROCESS NITRIDING

You can reduce or completely eliminate grinding, lapping or superfinishing time and cost after hardening with the Floe Nitriding Process.* On gears and splines and similar parts, your savings may run as high as 70 cents, or even more, out of every dollar otherwise spent on these finishing operations.

This is made possible by three characteristics of the process:

1. A surface with a minimum of "white layer" which is ideal for service with no after grinding or lapping operations.
2. Low temperature hardening and
3. Elimination of quenching – both of which minimize distortion.

In most instances, the surface is ready for service.

In addition, the Floe Process applied to any Nitralloy or other alloy steel suitable for nitriding gives you these other important advantages:

- superior case structure
- high wear resistance
- high fatigue resistance
- retention of hardness at high temperatures
- excellent core properties

This New Treatise will show you how the Floe Process can cut *your* finishing costs. Send for your copy.

PRODUCERS AND DISTRIBUTORS

Custom heat treaters and users of nitriding steels may obtain licenses for this process without limitation as to the source of supply.

Purchasers of Nitralloy steels from any of these producers or distributors automatically acquire the license to use the Process in converting the steels so purchased.

Joseph T. Ryerson & Son., Inc., Chicago, Milwaukee, St. Louis, Detroit, Cincinnati, Cleveland, Pittsburgh, Philadelphia, Charlotte (N.C.), Buffalo, New York, Boston, San Francisco, Los Angeles, Spokane, Seattle.
The Earle M. Jorgensen Co., Los Angeles, Oakland, Houston, Dallas, Tulsa.
Bowsteel Distributors, Inc., Linden, N. J.
Atlas Steels Limited, Welland, Ont.
The Babcock & Wilcox Co., Beaver Falls, Pa.
Copperweld Steel Company, Warren, Ohio
Firth-Sterling Steel Co., McKeesport, Pa. (Nitrard steel only)
Rotary Electric Steel Co., Detroit, Mich.
Grede Foundries, Inc., Milwaukee, Wis.
Electric Steel Foundry Co., Portland, Ore.

*Patent No. 2,437,249

THE NITRALLOY CORPORATION • 230 PARK AVE., NEW YORK 17, N. Y.

A SPECIAL REPORT ON PROTECTIVE FINISHES FOR ALUMINUM

Most aluminum producers and fabricators are well aware of the superiority of chemical finishes over anodizing for the protection of aluminum from corrosion. Naturally, then, there is a running battle for acceptance among the leading producers of the protective chemical finishes.

That's why, here at Allied, we have always studied your needs with regard to both our own and competitive processes. We're constantly trying to produce new and better finishes because we believe there's always room for improvement . . . even to our own products. Some years ago this policy led to the introduction of a process, long in development, that offered you a way to overcome anodizing's obvious technical complications . . . Iridite #14. This finish was far easier to use than anodizing, yet provided comparable, if not superior, quality. And, its cost was much less than anodizing.

But other finishes offering similar advantages over anodizing have entered the market. So . . . the current battle for acceptance. By any cost comparison Iridite #14 is the most economical. However, corrosion tests by users show contradictory results as to performance from Iridite #14 and other leading protective finishes for aluminum. Most tests show Iridite #14 superior, but some do not. The margin of difference, however, is always small. The truth is that all have proved good. However, our laboratory research indicated that still further improvements could be made.

That knowledge . . . plus our aim to give you even better protection and maintain the leadership of the industry, is exactly why Allied Development Engineers have been working for long years to develop a better finish than any of those now available, including our own Iridite #14.

Now the new finish is ready for you. It's called Iridite #14-2 (Al-Coat).

From a performance standpoint, Iridite #14-2 gives you two important advantages in the protective finishing of aluminum.

FIRST: in its fully colored brown film stage it provides corrosion resistance decidedly superior to previous processes.

SECOND: the basic brown film can be hot water bleached to produce a clear-type film with protection heretofore unobtainable from clear-type chemical finishes.

From an operating standpoint, new Iridite #14-2 gives you three important advantages.

FIRST: it provides consistently higher corrosion resistance for different aluminum alloys treated in the same bath.

SECOND: it provides a more uniform appearance for parts of different alloys and with varied surface finishes before treatment.

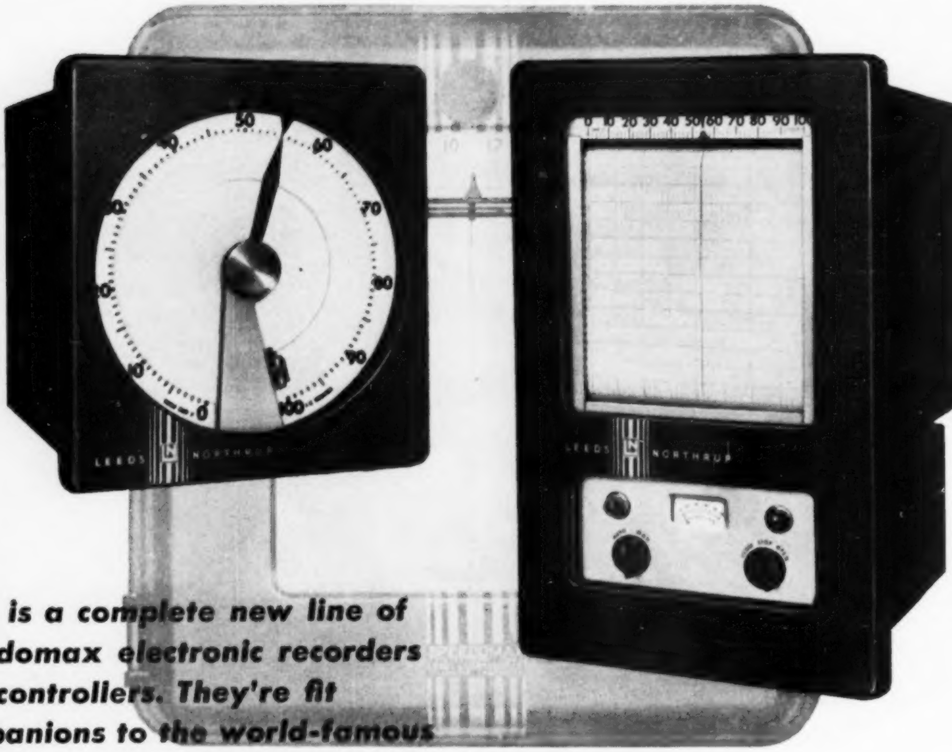
THIRD: its operating and technical characteristics are superior to those of other processes.

If you are using or planning to use a chemical finish for aluminum, you should have full details on new Iridite #14-2. Write us or send samples for free test processing. Or, for more immediate advice, call your Iridite Field Engineer. He's listed under "Plating Supplies" in your classified telephone book. - - - ALLIED RESEARCH PRODUCTS, INC., 4004-06 EAST MONUMENT STREET, BALTIMORE 5, MARYLAND.

P. S. Even new Iridite #14-2 will be constantly measured against both your needs and competitive processes to make sure you get the best possible, most economical finish for your product that man and the laboratory can develop.

New, compact

Speedomax® Instruments can modernize process control in hundreds of plants!



Here is a complete new line of Speedomax electronic recorders and controllers. They're fit companions to the world-famous Speedomax Type G. They are called Type H.

These new instruments can help the operation of a tremendous variety of industrial processes—including many which are perhaps now under-instrumented. And L&N's new production techniques bring Speedomax H equipments within reach of processes which couldn't formerly justify high-quality electronic potentiometers.

Especially significant to operators who now employ filled-system and deflection instruments are the benefits of electronic potentiometer performance. For instance, you can install Speedomax wherever you wish, without a thought for the distance to its sensing element. And Speedomax won't "drift" in accuracy as it ages—it stays on the job and holds the process on spec. If you damage either the sensing element or lead, you simply repair or replace on the job. Speedomax never goes back to the factory for re-calibration, so you do not need spares—thus you save both inventory and storage space.

Anyone familiar with L&N construction will see it again in Type H. The same husky components, anti-friction bearings, rigid assembly and ultra-accessability.

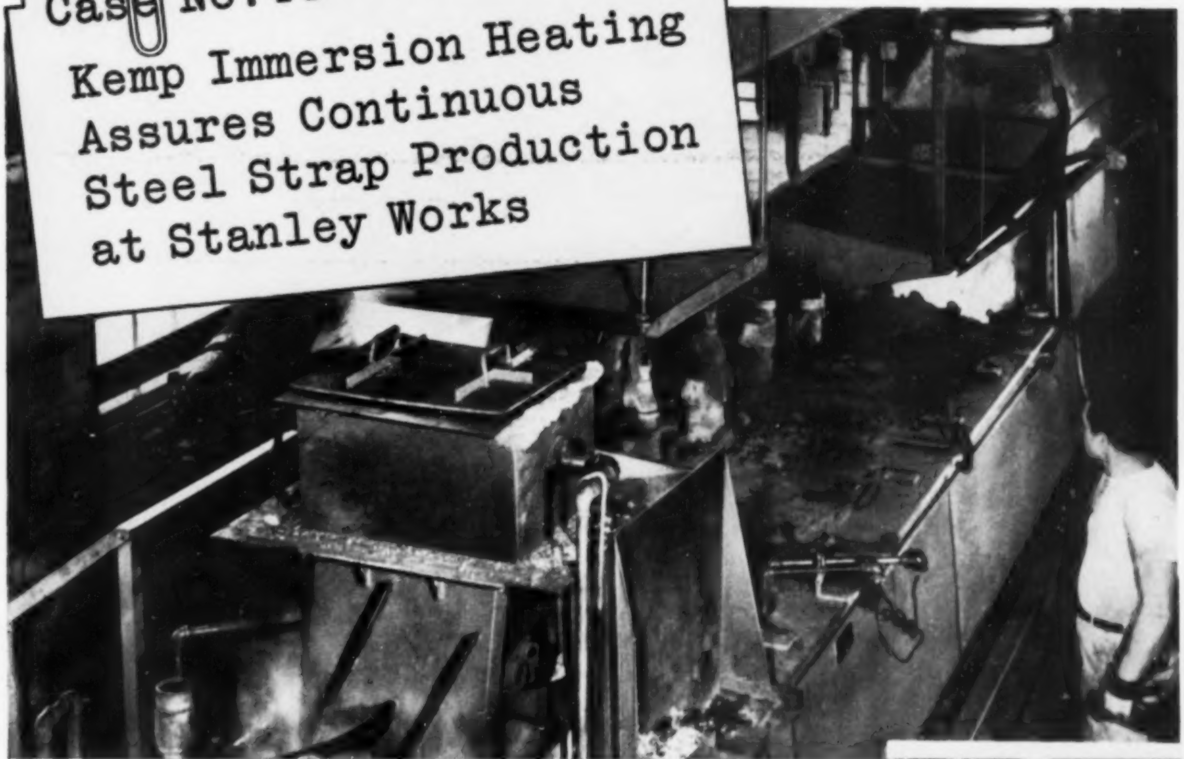
New features include a "fill-in-place" pen; a new, ingenious on-off control switch; more plug-in components. External leads go to a terminal board on outside back of case, for easy installation and maintenance.

One of the round-chart instrument's special features is its long scale; this is used both in setting the control point and for reading temperature. All instruments have especially easy, accurate means for moving the control point setter.

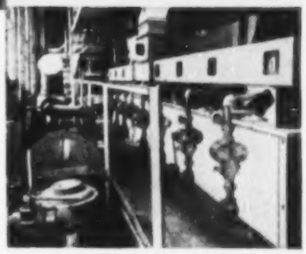
You can choose any type of control action—On-off; Proportional Action; Proportional with rate and reset actions. Any L&N office can supply details and application engineering assistance; or write us at 4927 Stenton Ave., Philadelphia 44, Pa.

LEEDS & NORTHRUP
instruments · *automatic controls* · *furnaces*

Case No. 44
Kemp Immersion Heating Assures Continuous Steel Strap Production at Stanley Works



How Stanley doubled steel strap capacity overnight ... slashed fuel costs, too



Rear view of Kemp Pot at Stanley Works shows gas feed lines, fire checks, and the Kemp Carburetor (left). Part of every Kemp installation, this carburetor assures complete combustion ... without waste ... without tinkering. Just set it, and forget it.

Today this bustling division of the famous Stanley Works at New Britain, Conn., turns out steel strapping on a 24 hour basis. Starting with raw, high carbon steel on giant spools, strap is semi-annealed, finished, coated and rewound again for shipping in one *continuous* process. New rolls of raw steel are simply spot-welded to the ends of rolls to eliminate any interruption.

Kemp Eliminates Bottleneck

From an output limited by the capacity of a gas underfired pot, production was doubled on the installation of a 32 ton Kemp Immersion Melting Pot. In addition, Kemp's *greater* heating surface, *faster* heat recovery, *lower* dross formation and *accurate* temperature controls meant real savings in fuel costs. In the words of Mr. Harold Heckman, plant foreman, "Through quicker heating of this pot, we are able to maintain production schedules." And unlike underfired pots, Kemp units eliminate open flame hazards and excessive room temperatures.

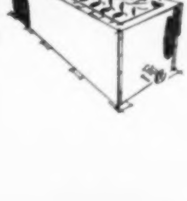
Let Kemp Help with Your Problems

If you're dissatisfied with your present heating or melting equipment, consult Kemp first before you make any changes. Let Kemp Engineers show you how they can solve your tempering, annealing, descaling or coating problems quickly and easily. Then just like the Stanley Works, you'll be *time* and *money* ahead.

For more complete facts, ask for Bulletin IE-11. Write: C. M. KEMP MFG. CO., 405 East Oliver Street, Baltimore 2, Md.

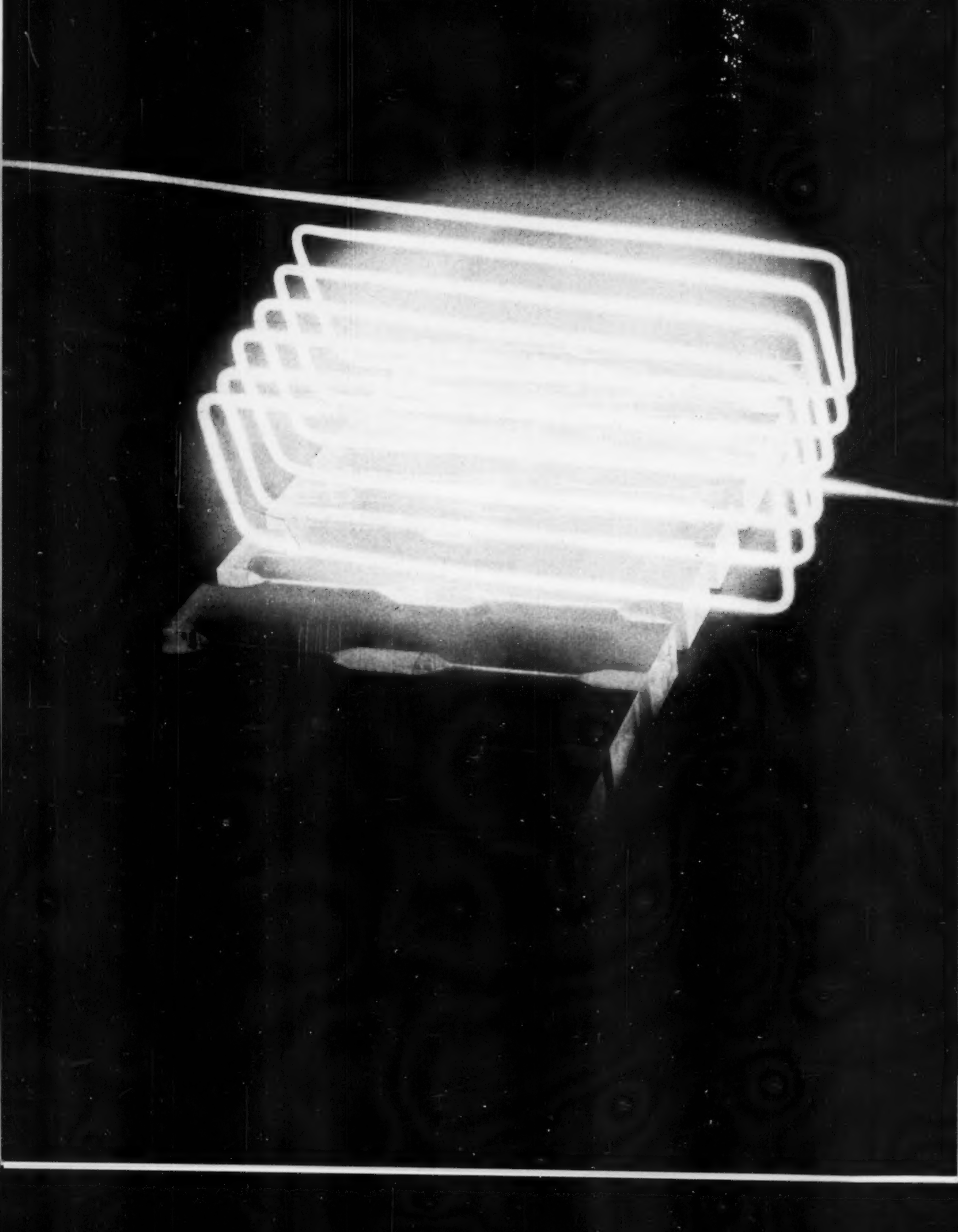
KEMP OF BALTIMORE

IMMERSION MELTING POTS



CARBURETORS • BURNERS • FIRE CHECKS
ATMOSPHERE & INERT GAS GENERATORS
ADSORPTIVE DRYERS • SINGEING EQUIPMENT

ANOTHER WESTINGHOUSE FIRST IN INDUCTION HEATING FOR FORGING . .



WELDCO TUBING USED BY FIRESTONE STEEL PRODUCTS CO. *to Fabricate Army Tank Mufflers*

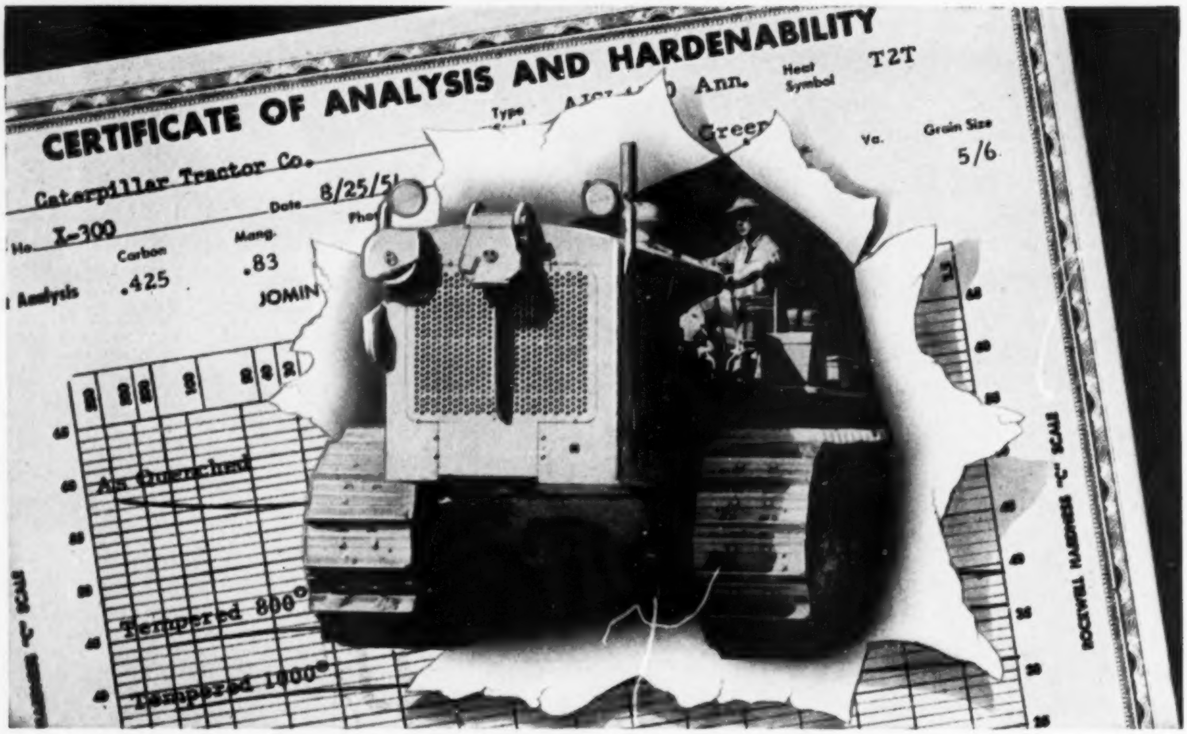
WELDCO Type 430-T Welded Stainless Steel Tubing was used in the tank muffler shown above. It was chosen for **ALL** the tubular parts because it met the heavy-duty requirements of this application. Firestone Steel Products Co., Akron, Ohio, specified WELDCO Tubing because of its exclusive Double-Fusion Weld and excellent fabricating qualities.

WELDCO Pipe and Tubing are available in Monel, Stainless Steel, Hastelloy, Inconel, Nickel, Cupro-Nickel, and Carbon Steel . . . in sizes 3" and larger, in Schedules 5 through 120. In addition, intermediate wall thicknesses and outside diameters can be produced to your specifications. For any special problems or regular applications, always specify WELDCO — Your Best Buy in Top Quality Tubing.

WELDCO

Whatever Your Needs In Tubing . . . You're 'Way Ahead With WELDCO

THE YOUNGSTOWN WELDING & ENGINEERING CO.
3718 OAKWOOD AVE. · · YOUNGSTOWN 9, OHIO


CERTIFICATE OF ANALYSIS AND HARDENABILITY
Caterpillar Tractor Co.
X-300
Carbon
.425
Mang.
.83
T2T
Grain Size
5/6
As Quenched
Tempered 800°
Tempered 1000°

Metal Progress

Vol. 66, No. 5 November 1954

Critical Points . . .

BY THE EDITOR . . .

Canadian Stainless Sheet Mill

CONSTANT readers of *Metal Progress* will remember several descriptions of commercial methods of continuous casting. First was Alcoa's "direct chill" process for aluminum alloys developed between World Wars by Ennor and his associates, although this is intermittent in the sense that a single slab is continuously cast, then removed, whereupon the process restarts. Dow's magnesium mill uses true continuous casting; the end of the lengthening billet is sawed off at appropriate intervals. The latter scheme is also the basis of Scovill's new sheet mill in Waterbury – one of six similar casting units now operating in the copper and brass mills in America. American Smelting & Refining Co. also has its own process in operation on rounds, tubes and shapes.

Steel casting, as observed at Babcock & Wilcox's pilot plant, was described in "Critical Points" in the March 1953 issue. Now the Editor is pleased to report that our Canadian brothers at Atlas Steels, Ltd., of Welland have slipped in ahead of the usually enterprising Yankees with a completely new department for stainless steel slabs, strip and welded tubing starting with a continuous casting machine designed by Koppers Co., Inc. of Pittsburgh, capable of casting 5½ x 21-in. slabs at the rate of 30 tons per hr. A heat of electric furnace steel, poured some 20° hotter than usual, is transported to the casting machine in a preheated and covered ladle. This ladle pours over a lip into a tun dish; the steel passes under a slag skimmer and into the mold through a nozzle made of stabilized zirconia. As in all the other continuous processes, the mold is open at the bottom; in the Welland installation it is a chromium-plated water-cooled copper collar, 20 in. high; it is lowered with the descending slab for 3 or 4 sec. and then raised rather rapidly about an inch, whereupon it resumes its downward travel. The Editor would judge that the principal advantage of the reciprocating mold is that that portion of the mold which meets the molten steel can thus be adequately lubricated by a fine spray of oil; otherwise it appears that the mold scores quickly and badly.

Just below the mold the descending slab (really a thin shell of solid with liquid interior) goes through a deluge of water in a closely spaced set of small rolls supporting the tender metal, thence through pinch rolls and on down to flying "shears" – a pair of oxy-acetylene cutting torches. The hot slab's surface (as it is transferred to reheating furnaces at, maybe, 1500° F.) looks remarkably smooth.

Obviously, speed of casting depends on speed of heat extraction. This involves a nice balance of pouring temperature and spray cooling. Pouring should be as cool as possible, yet the zirconia orifice cannot freeze. Water chilling, if too fast, creates contraction strains and internal cracks; 6-in. squares or slabs might be the practicable maximum. G. C. Olsen, Atlas's mill superintendent, estimates that increased yield over conventional ingots will represent most of the ingot crop – 10 to 20% depending on length and hot topping procedure.

The continuous caster is not the only unique

thing in the new Atlas department. Slabs are bloomed to about 2¾ in., automatically scarfed with Linde's oxy-acetylene flame carrying iron powder, descaled in a "Wheelabrator", and spot ground for remaining small defects. (95% of the hand work is saved right here.) Then the long billets creep at 6 ft. per min. through an R. S. Products' heating furnace, 70 ft. long, emerging at 2250° F. for the Canadian-made Sendzimer planetary mill. Thence to cold rolls, picklers, and other finishing units, including "Heliarc" welders for longitudinal seams in tubing, draw benches, test equipment, and so on. Very nice!

The planetary mill warrants a second look. The hot slab must be *pushed* into the mill by two sets of pinch rolls, and the mill reduces a 2¼-in. slab to 0.10 in., 96% in *one* pass, the sheet emerging at 135 ft. per min. Draw a diagram: Two main rolls, 27-in. diameter, are driven at 300 rpm. in the same direction as in an ordinary two-high mill. Around each of these are spaced 24 small rolls, 3½ in. diameter. Each set therefore looks like a big roller bearing with no outer raceway. These outer work rolls have end-bearings socketed in cages which are driven at 130 rpm. There is no slippage between the big and little rolls, so it will be seen that the surfaces of the small work rolls are moving in a direction *opposite* to the passage of the hot slab. In action, the mill sounds like an oversized swaging hammer. No wonder it takes a hefty and continuous shove from the pinch rolls to feed the hot slab up against these counterspinning work rolls. When one slab is finished, a trailing one, abutting against it, keeps pushing.

It took a real inventor to think that one up.

Beware Explosions and Fires

Time was – and not so very many years ago – when work in smelters and steel mills was as hazardous as railroading. Then the safety engineers got busy with such notable success that now a man is safer at his job in a shop or on the assembly line than he is in his own backyard. But don't let us feel too virtuous – exactly the contrary situation exists in the metalworking industries as far as fire and explosion hazards are concerned. In the last decade there occurred the staggering number of 175 "large-loss" fires (meaning those costing more than $250,000) compared with 18 in the previous decade – a ten-fold increase. Money losses totaled 150 million, and this is 17 times as much as during the 1930's!

What caused this sudden increase? "Technical Survey No. 2" of National Board of Fire Underwriters lists no less than 12 factors. No. 1 (causing history's most expensive industrial fire at Livonia near Detroit in 1953) is the trend toward building *very* large plants under a single high-ceilinged roof, free from firewalls to give maximum ability to change machinery and production lines, and made of unprotected "fireproof" material which buckles and collapses quickly in a flash fire. The Livonia fire was spread rapidly by a rain of flaming asphalt, dripping from the roof-covering, in advance of the fire below.

No. 2 Fire Demon is something the metallurgical engineer can do something about, more directly. It is illustrated by the explosions and fire in an aluminum utensil plant in Chicago in 1953, killing 35 people and badly injuring as many more. This antiquated building contained a large number of sanding, polishing and buffing machines all served by a single dust-collecting system. An accident to one sanding belt threw a shower of sparks into the exhaust; the first small explosion stirred up all sorts of fine metal dust, buffing lint and wax accumulations; a series of resulting blasts scattered flaming cleaning oil over the premises, and the workmen didn't have a Chinaman's chance.

Lastly, a number of causes of serious disasters fall within a single category – and here again the metallurgical engineer can raise hell until any bad situation in his plant is corrected. They have to do with the rapid accumulation of new processes; new protective atmospheres; new and flammable lubricants, quenches, coolants; wood, plastics, rubber, and synthetics mixed up with the noncombustible metal in production – all of which were foreign to the metalworking industry a generation ago. An instance of how this leads to trouble is the Los Angeles explosion in 1947 which demolished an electroplating plant, wrecked 26 surrounding residences, killed 17 persons, and injured 200. An electropolishing solution, made up of perchloric acid and acetic anhydride, overheated when the motor on the refrigeration system burned out. Simultaneously, plastic work-racks (of all things, installed only the day before), dissolved away, and immediately a block buster explosion sent everything in the region including foundations 8 ft. down into kingdom come.

The reader of this article could do no better than write M. M. Braidech, director of research for the Fire Underwriters, 85 John St., New York City, for "Technical Survey No. 2" and spend some hours with his management studying it.

Round Table on Atmosphere Generation

In any broad consideration of furnace atmospheres and their applications, as was the panel discussion conducted by the Industrial Heating Equipment Association and the A.S.M. on Nov. 2 at the National Metal Congress, it would be well to start with a brief consideration of the fundamental scientific principles governing the reactions between hot metal and hot gases

Theory of Gas Atmospheres

*By A. G. HOTCHKISS**

Modern industry relies heavily on prepared furnace atmospheres. Many important processing methods of wide industrial application – such as copper, silver and aluminum brazing, and the sintering of powdered metals – are completely dependent upon their availability in large quantities at reasonable cost.

"Furnace atmosphere" means a gas or combination of gases used to displace air in a furnace chamber. Air is also a gas, so let's first ask "What is a gas?" My old chemistry book states that "gas is matter in such state that it distributes itself uniformly throughout the space in which it is confined" . . . also that "gas mixtures do not stratify but mix in complete and permanent diffusion when put together in a container."

These characteristics, together with the fact that gases behave according to well-established laws, permit them to be used in furnace envelopes of almost any size and shape, to surround the work being treated. If properly selected, they prevent, minimize, or control changes to the surface of this work when at elevated temperatures.

The common gases when considered in respect to metals are said to be

1. Inert or neutral – that is, when no reaction takes place.
2. Oxidizing – when some oxygen in the gas combines with the metal.
3. Reducing – when the gas reacts at elevated temperatures to reduce oxides to metal.
4. Metallurgically active – when some constituent is added or taken away from the work, such as the addition or extraction of carbon from a steel surface.

Gases may also be considered in three different groups as in Table I, namely, as elements or single gases, in chemical combination, and as mixtures of two or more gases.

Elemental Gases – In the top part of Table I, we have listed five gaseous elements, argon, helium, nitrogen, oxygen and hydrogen, and the table shows that their reaction with ferrous and nonferrous metals at elevated temperature is exactly the same. Two of these inert or neutral

*Industrial Heating Dept., General Electric Co., Schenectady, N.Y. Mr. Hotchkiss and his associate, H. M. Webber, wrote the general article on "Protective Furnace Atmospheres" in Metals Handbook, 1948 Edition, p. 294, which briefs much of the information in this and the next five articles.

Table I – Effect of Various Gas Atmospheres on Hot Metals

Gases Classified as	Ferrous Metals					Nonferrous		
	Inert	Oxidizing	Reducing	Decarburizing	Carburizing	Inert	Oxidizing	Reducing
Elements								
Argon, A	X					X		
Helium, He	X					X		
Nitrogen, N_2	X					X		
Oxygen, O_2		X					X	
Hydrogen, H_2			X					X
In Chemical Combination								
Water, H_2O		X		X		X		
Carbon dioxide, CO_2		X		X		X		
Carbon monoxide, CO			X		X			X
Methane, CH_4			X		X			X
As Mixtures								
N_2+H_2			X					X
$N_2+H_2+H_2O$		X or	X	X				X
$N_2+H_2+H_2O+CO_2+CO$		X or	X	X or	X			X
N_2+H_2+CO			X		X			X

gases, argon and helium, are rare gases and not used for industrial furnace atmospheres although they are very useful in the shielded-arc welding processes. Nitrogen, however, exists in widely varying amounts in most of the atmospheres commonly in use.

Oxygen is generally the main element we desire to remove from a furnace chamber, or prevent from entering it.

Hydrogen is the most active reducing gas and is found in the common prepared atmospheres in amounts varying from 100% to a fraction of 1%. Both hydrogen and nitrogen, because they were readily available, were used in early experiments and commercial applications. Copper brazing of steel parts was introduced before 1920; Fig. 1 shows a 1925 furnace for copper brazing refrigerator parts in hydrogen.

Gaseous Compounds – The middle part of Table I lists four common gases whose molecules are chemical compounds. Water and carbon dioxide are alike in their reactions, being oxidizing and decarburizing to ferrous metals but neutral toward nonferrous metals. Likewise, carbon monoxide and methane have similar reactions to hot metals, being reducing and carburizing to the ferrous type and reducing to the nonferrous.

From the historical standpoint, steam was one of the first atmospheres to be used for protecting copper. Steam-filled water-sealed annealing furnaces were in use before 1905, and a few are still in existence. The process of adding carbon to iron through its surface to produce steel is centuries old, even though the steelmakers did not know that was what was happening. The use of a gas such as methane to supply the carbon and furnish the protective conditions required was introduced to European industry about 1908. The papers on p. 106 to 118 of this issue will describe atmospheres for carburizing.

Gaseous Mixtures – We now come to the bottom third of Table I which lists the most widely used types of atmosphere.

One of the first mixtures used in the early 1920's was nitrogen and hydrogen when it was found that about 15% H_2 would do many jobs and was much less dangerous to handle than substantially pure gas. Dissociated ammonia (75% H_2, 25% N_2) was used in the late 1920's; it is still an important atmosphere and will be discussed in a later paper.

The mixture in the second line naturally results when the above mixture combines with any oxygen in the furnace or any oxide on the work. Adding water vapor may change the reaction with ferrous metals (depending upon conditions to be discussed later) from reducing to oxidizing or from neutral to decarburizing.

The most widely used atmosphere today is represented by the next to last line in the table. This combination results from the combustion of a fuel gas in deficient air for complete combustion. Because the ratios of the gases in this mixture can be varied between quite wide limits, it can be either oxidizing or reducing to iron, carburizing or decarburizing to carbon steels.

Years and years before special atmospheres, operators of fuel-fired furnaces could control the atmospheres so as to reduce scaling by adjusting the burners to give a "soft" or "reducing" flame. However, the use of a separately controlled "exothermic"* generator to produce this type of atmosphere was started in the early 1930's (Fig. 2). The "exothermic" type now produces gas mixtures ranging from neutral to fairly reducing

*"Exothermic" because its operation generates surplus heat.

(when the surplus moisture is condensed out). "Endothermic"* generators produce a strongly reducing atmosphere; controls can be set so as to eliminate almost all the CO_2 and H_2O, whereupon the generated gas is similar to the mixture in the last line of the table which is definitely reducing and carburizing.

As noted, all these mixtures are reducing to most nonferrous metals.

Exothermic and endothermic atmospheres will be fully discussed in the next two papers.

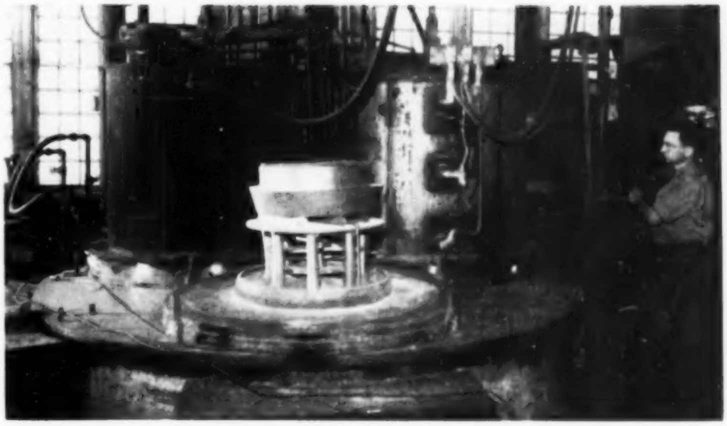


Fig. 1 – Three-Stage Bell-Type Furnace for Copper Brazing or Bright Annealing Refrigerator Parts in Commercially Pure Hydrogen. The date: 1925; the location General Electric's Schenectady Works. Loading station in foreground; hydrogen displaces air in small covered work container, bells hoist, large circular foundation plate indexes 120° counterclockwise, bells lower. At end of heating cycle, bells again rise, foundation indexes 120° more, and cover at left rear regulates cooling rate.

Theoretical Equilibrium

Certain data on the chemical reactions can be used to predict the proper mixture of gases for a given job. These are shown on p. 85, which is a reproduction of *Metal Progress* Data Sheet No. 80.

The diagram at the lower right shows the relationship between iron and iron oxide with various ratios of H_2O with respect to H_2, and of CO_2 with respect to CO. Referring to the curve in solid line, the area above is in the oxidizing range while the area below is in the reducing range. Therefore, if an atmosphere contains equal amounts of CO and CO_2 – that is to say, ratio $CO \div CO_2 = 1.0$ – it should be possible to heat clean iron in this atmosphere to approximately 1000° F. without any blueing or discoloration. However, if the temperature is increased to 1100°, the condition falls on the oxidizing side of the curve and oxidation would be expected according to the reaction $FeO + CO \leftarrow Fe + CO_2$.

The dotted curve in this same diagram shows the equilibrium values for H_2, H_2O, Fe and FeO. Again, the area to the left of the curve indicates reducing conditions and the right indicates oxidation. The oxidizing action of steam on steel below 600° F. is too slow to be a matter of concern in commercial heating practices. A gas containing 5% H_2O and 95% H_2, with a ratio of H_2O to H_2 of about 0.05 and represented by the dotted ordinate a-a', will not oxidize bright steel at any temperature, and in that sense is "neutral". In fact, any iron oxide would tend to be reduced.

Assume, however, a gas containing 3.7% H_2O† and 15% H_2, or a ratio of 0.25, at 1200° F. This point plots at b' and is well within the reducing range. However, when the temperature drops to 975° F., the plotted point crosses the theoretical equilibrium curve along the line b'-b, and enters the oxidizing range. It would, therefore, be impossible to slow-cool steel in such an atmosphere without oxidation (coloration).

Supposing, now, we have a mixture containing all four of these gases, as would be obtained from the partial combustion of a hydrocarbon, the situation changes. The theoretical equilibrium curve for $CO:CO_2$ crosses that of $H_2O:H_2$ at about 1500° F. Therefore, if we have, say, 5% CO_2 and 10% CO in the above gas mixture, along with the hydrogen and water vapor, the ratio of the carbon gases ($CO_2:CO$) which is 0.50 and plotted at B-B' shows this mixture to be quite strongly reducing at 1200° F. and increasingly so as the temperature decreases, thus overcoming the mildly oxidizing nature of the moisture content. It is possible, therefore, with the four gases mixed in proper proportions, to cool steel through the dangerous range and reach 800° F. without oxidation.

*"Endothermic" because heat must be supplied to maintain the reaction.

†This would represent saturation at 82° F., and it is said that such a gas has a dew point of 82° F. because liquid water would be deposited from it if cooled below that temperature.

A. G. Hotchkiss

Aside from a stretch in the anti-aircraft division during World War II, Mr. Hotchkiss has spent his working life in G.E.'s industrial heating department, and is now manager of furnace and associated equipment engineering. Long-time ASMember, he is co-author with H. M. Webber of "Protective Atmospheres", published in 1953 by John Wiley & Son.

Carburizing Reactions – The theoretical relationship between CO, CO_2, Fe and Fe_3C is indicated in the following reversible equation:

$$CO_2 + Fe_3C \rightleftarrows 3Fe + 2CO$$

This equation shows that to maintain an equilibrium between the gas and the iron carbide, a certain relation between CO and CO_2 must exist, depending not only on temperature but also on carbon content of the steel, as shown in the top right diagram on p. 85. It is important to note that any single ratio of CO to CO_2 is neutral to a steel of only one carbon content and at only one particular temperature.

For instance, a gas containing nine times as much CO as CO_2 would be neutral to 0.2% carbon steel at 1700° F. (point B), but at the same time would carburize a 0.10% carbon steel and decarburize a 0.40% carbon steel. Also, if the same ratio of gases was maintained and the temperature increased, the 0.2% carbon steel would tend to be decarburized, whereas if the temperature was decreased below 1700 it would be in a carburizing range. In practice, then, to prevent decarburization it is generally important to establish an equilibrium at the maximum temperature of treatment, since reaction rates increase with temperature.

The most active carburizing gases, however, are the hydrocarbons, such as menthane, CH_4. Thus, we have

$$CH_4 + 3Fe \rightleftarrows Fe_3C + 2H_2$$

This reversible equation shows that, again, control is based upon an equilibrium of two gases CH_4 and H_2. The diagram at top left on p. 85 clearly shows that the reaction is dependent on the carbon content of the steel. Any combination of gas analysis and temperature in an area to the right of a given cruve will be in a carburizing range. On the other hand, any gas that contains more hydrogen than the equilibrium mixture requires will tend to decarburize. However, at the higher temperatures this would demand a large proportion of hydrogen; in other words, the presence of a relatively small amount of methane in a gas tends toward carburization.

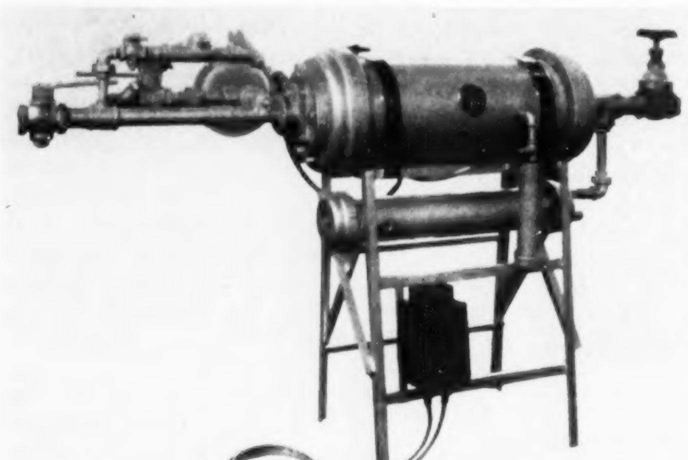
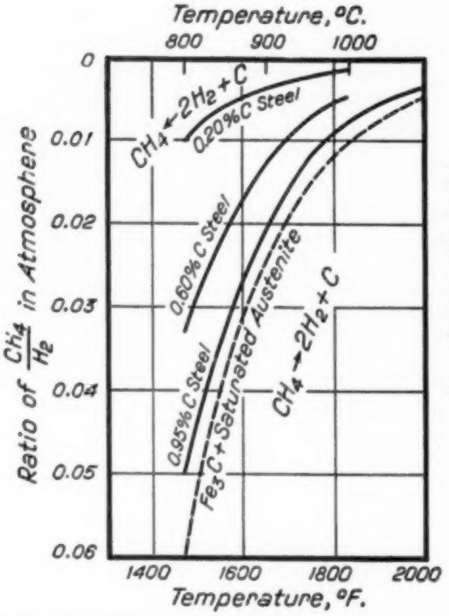


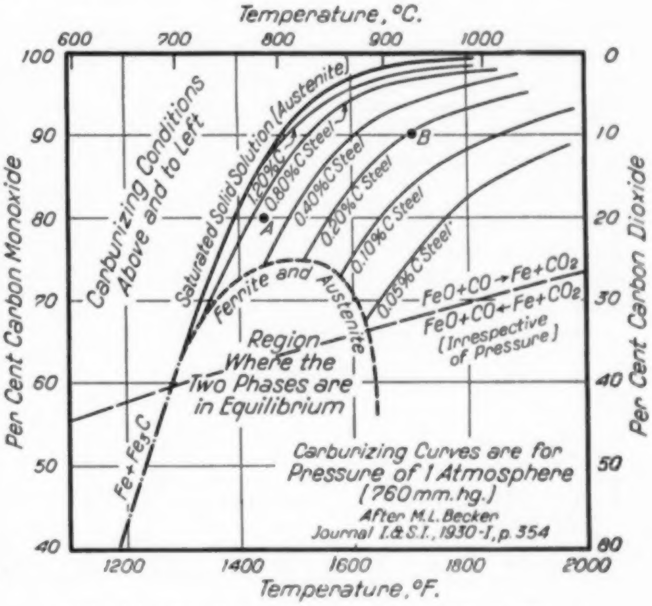
Fig. 2 – An Early Design (1931) of a Gas Generator for Exothermic Atmosphere Making 500 Cu.Ft. per Hr. The combustion chamber is merely a refractory-lined 12-in pipe with cast iron caps at either end.

Equilibria for Gas-Steel Reactions

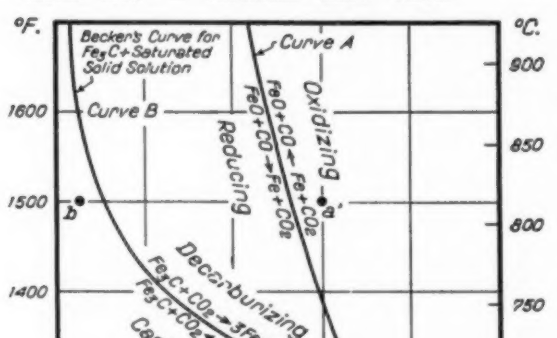
Relation Between Gas Composition, Temperature, and Carbon Content in Steel for Pressures of 1 Atmosphere



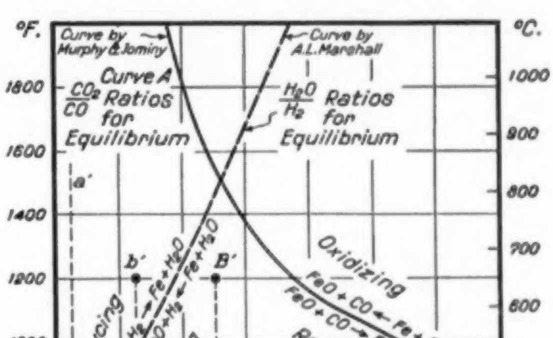
Above Curves, Adapted by Stansel From Sykes' Work, Indicate That Almost Pure H_2 Decarburizes Hot Steel (Conditions Above and Left of Corresponding Curves). Methane breaks down almost completely into carbon and hydrogen, carburizing steel (and depositing excess soot) at conditions below curves



Carburizing Reactions Depend on Carbon in Steel, Thus: 80% CO, 20% CO_2 at 1450° F., (point *A*) will carburize 0.40% C steel and lower, but decarburize 0.80% C steel and higher. However 90% CO, 10% CO_2 at 1700° F., (point *B*) is relatively inert to 0.20% C steels, will carburize lower carbon and decarburize higher carbon steels. Partial pressures, i.e., $CO + CO_2 < 100\%$, raise curves and shift to left



Action of Carbon Oxides Depends on Temperature. For instance, a dried atmosphere containing 6% CO_2 and 10% CO or ratio 0.6 (easily secured by partial combustion of fuel gas) would tend both to reduce and carburize at a 1225° F. anneal (Point *a*), but would both decarburize and oxidize at 1500° F. (Point *a'*). For "bright hardening" the CO_2 must be reduced well below Curve *B* (for instance, 1/10 the CO, as Point *b*, at 1500° F.). The above statements neglect the fact that the pressure of $CO + CO_2$ is less than 1 atmosphere



Oxidizing Action of Steam May Be Counteracted by 20 Times As Much Hydrogen (Line *a-a'*). Larger proportions of steam may scale the metal during cooling (line *b'-b*). Oxidizing — and decarburizing — propensities of moist gas may likewise be counteracted by carrying excess CO in the mixed carbon oxides present in the furnace atmosphere (for instance, CO_2 : CO = 0.5, or line *B-B'*, on the reducing side of curve *A*)

This is an important fact in furnace atmospheres for treating carbon steels.

Since most of our commercial atmospheres contain H_2, there is almost always a reaction in the furnace chamber which forms steam, H_2O. With respect to carbon "potential" (tendency to carburize), this water vapor is a neutralizer; the higher the dew point, the lower the carbon potential, and dew-point measurements can be used as a direct indicator of carbon potential of a given atmosphere.

It is difficult to calculate equilibrium curves for atmospheres containing several gases, and they may not be reliable.* A more useful scheme is to establish, by actual furnace test, families of curves for the different steels under different temperatures. This practice, as well as dew-point control, will be discussed in later articles.

The equilibria just discussed show various gas combinations required under specific conditions, precisely controlled. In heat treating it should be remembered we always deal with a furnace atmosphere surrounding the work, and there are many factors which may affect actual production. The theoretical data are useful mainly as a guide to what may happen.

*In the discussion, Charles A. Mueller, assistant director of research for Lindberg Engineering Co., pointed out that a little ammonia (NH_3) shifts the equilibrium curves to higher carbon potentials. Also that some alloy and toolsteels do not react with atmospheres as would be expected with nonalloyed steels of the same carbon content.

Exothermic Atmospheres– Their Generation and Application

*By W. H. BOYD**

The earliest and simplest of the atmosphere generators, the exothermic type, has widest application for heat treatment of constructional alloy and carbon steels. When dried to dew points around –40° F. by solid desiccants, this atmosphere is especially reliable in continuous furnaces which must have entrances and exits open at all times.

ALTHOUGH the desirability of surface protection was recognized by the toolsmith, equipment for producing special atmospheres for controlling the surface and analysis of the heat treated material, and the technique of applying it, are the result of progress in the last 25 years. In fact, major improvement in equipment can be noted in the past ten. The process and resultant product are often controlled by rule of thumb; however, there exists a sound and logical background so uniform results can be guaranteed in continuous production.

Although today there are many classifications of gases and new mixtures are being constantly developed, the atmosphere generators can be classified into two basic groups – the exothermic type to be further discussed in this article, and the endothermic type described by Mr. Perrine in the next article. The first named is the simplest and probably the most widely used of all.

Webster defines exothermic as "characterized by or formed with the evolution of heat". Consequently an exothermic atmosphere is produced in a generator which burns fuel and air in such a manner that combustion is supported and reactions proceed without outside help.

Futher, exothermic generators are of two types – a high-ratio operating unit termed an "inert" generator and a low-ratio operating unit termed a "de-ox" generator (trade-named "Annealing

*Manager of Sales and Operations, Gas Atmospheres, Inc., Cleveland.

Generator", "DX Generator", "Exo Gas Generator", and so on). Figure 1 shows the operating range for exothermic generators burning natural gas with the analyses of atmospheres produced at various air-gas ratios.

Inert atmospheres have some application in the nonferrous industry, such as annealing copper, various brasses and copper and nickel alloys, as well as for phosphor-copper brazing and silver soldering of copper or brass. This inert atmosphere has also been used for annealing stainless and high-carbon steel parts where the resultant surface is not critical and any oxide can be removed by light pickling or descaling. (This type of unit is also widely used in oil refineries for blanketing explosion and fire hazards.)

The low-ratio exothermic generator has its largest application in the metallurgical field, and for convenience, the term "exothermic" will be used hereafter to refer to this low-ratio type.

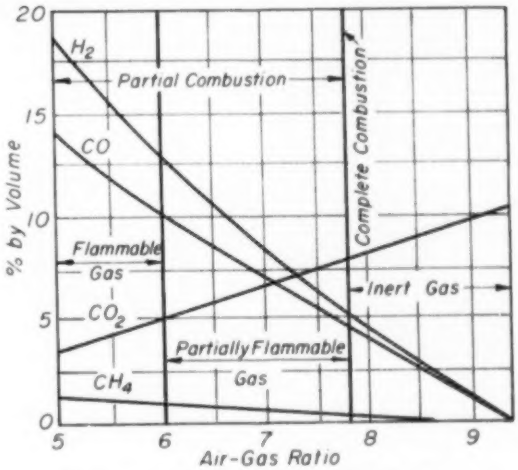


Fig. 1 – Analysis and Character of Exothermic Atmosphere Produced at Various Air-Gas Ratios (Assuming Fuel Gas to Be Natural Gas, Substantially Methane)

Combustion Unit

Basically, the exothermic generator consists of a combustion chamber wherein a metered and mixed volume of fuel and air is partially burned and partially dissociated. The result is an atmosphere relatively high in combustibles. More specifically, modern exothermic generators employ an air-gas metering and mixing system, a premix gas burner, a water-jacketed combustion chamber, a water-cooled (preferably a shell-and-tube) gas cooler, a water separator and trap, together with the necessary automatic controls, regulators, and safety devices. A typical flow diagram is shown in Fig. 2.

Constant maintenance of a correct ratio between fuel and air is of great importance; equally important is the design of the combustion chamber. Some of the most notable improvements in the past ten years have been in foolproof ratio controlling devices so that, once adjusted, the fuel-air proportion does not creep down (so as to form excessive carbon in the generator) or creep up (to upset the chemical relations required for satisfactory work). These devices include complex carburetors found on some units as well as simple diaphragm proportionators which control the pressure of gas in relation to pressure of air across fixed orifices.

Many designs of combustion chambers have been employed – units partially filled with broken refractories; units partially filled with scrap iron castings; units partially filled with impregnated catalyst material; units which are simply a straight, brick-lined chamber wherein the hot brick at 2000° F. or more provides the catalytic effect.

Its important function is to insure complete reaction (burning and cracking of the fuel) to the desired resultant gas. The fundamental combustion equations are

$$CH_4 + O_2 = CO_2 + 2H_2 \quad (1)$$
$$2\,CH_4 + O_2 = 2\,CO + H_2 \quad (2)$$
$$2\,H_2 + O_2 = 2H_2O \quad (3)$$

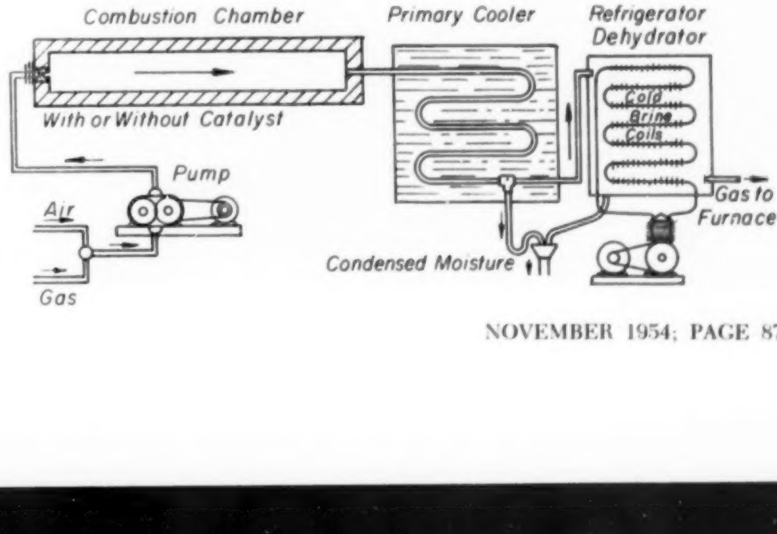


Fig. 2 – Schematic Arrangement of Atmosphere Producer and Dehydrater

W. H. Boyd

A Pennsylvanian by birth and education (Penn State in Mechanical Engineering), Mr. Boyd served four years in the Air Forces. Since 1947 he has been with Gas Atmospheres, Inc., successively as construction engineer, service manager, and manager of sales and operations.

Most of these reactions depend on time and temperature, so an efficient nickel catalyst is frequently employed to shorten the time required for the reactions to attain equilibrium, and to reduce the possibility of soot deposition in the furnace.

There are a number of reversible equations which form the theory back of the generation and application of exothermic atmospheres. The temperature and the concentration of the reagents influence the extent of these reactions. The more important are listed below:

$$C + CO_2 \rightleftarrows 2\,CO \qquad (4)$$

(producer gas reaction)

$$CH_4 \rightleftarrows C + 2H_2 \qquad (5)$$

(thermal decomposition)

$$C + H_2O \rightleftarrows CO + H_2 \qquad (6)$$

$$C + 2H_2O \rightleftarrows CO_2 + 2H_2 \qquad (7)$$

$$CO + H_2O \rightleftarrows CO_2 + H_2 \qquad (8)$$

(water gas reaction)

Equations (4) to (8) influence what happens in the combustion chamber of the generator and equations (6) and (7) are probably important only if there is considerable soot in the flame of the combustion chamber and if there is adequate time of contact with the catalyst to allow the soot to be oxidized. Equation (8) is perhaps the most important in determining what happens.

In the application of exothermic atmospheres, the moisture content is quite important. Generally, at the exit of the combustion chamber the gas contains 2 to 4% H_2O by volume. This will oxidize steel during heating and cooling cycles, as is shown at considerable length in the subsequent papers by Mr. Koebel (p. 110) and Mr. Cullen (p. 114). A small amount of water vapor is, however, required to obtain equilibrium of the component gases when at high temperatures; therefore, a refrigerant dryer follows the generator to reduce the temperature (and the dew point) to $+40^\circ$ F. – a moisture content of 0.8% by volume which is satisfactory for most uses.

Uses of Exothermic Atmosphere

However, additional desiccant dryers are employed by many metal treating firms to lower the dew point to -40° F. (about 0.01% H_2O by volume). With such a dry gas the moisture in the furnace can be better controlled, even though some water vapor will be formed through chemical reactions with infiltrating air, with oxide on the work, or by a change in equilibrium at the actual furnace temperature.

The atmosphere *in the furnace* is the important consideration. Purification of the gas, such as drying to -40° F., even though somewhat beyond what would be essential, is often a worthwhile safeguard for satisfactory work.

There is, of course, no one atmosphere applicable to all metal treating operations. Specifications sometimes vary but most important are such things as plant practice, cleaning procedure,

Fig. 3 – Typical Roller-Hearth Radiant-Tube Furnace for Bright Annealing Alloy Tubing in Exothermic Atmosphere With +40° F. Dew Point. Capacity, 3000 lb. per hr. Courtesy Drever Co.

construction of the furnace, and actual handling of the atmosphere generator. Often what works in a satisfactory manner in one plant would not even be considered practical in another. These differences – as well as more rigid specifications for materials – have necessitated further purification of the product even though the simple exothermic atmosphere described above has been employed widely in the past. As will be described by Mr. Beggs in his paper on p. 94, exothermic atmosphere is the first step in the production of useful nitrogen atmospheres and the more recent hydrogen-nitrogen atmospheres.

However, exothermic atmosphere still has retained a prominent spot because of ease of preparation, adaptability and economy. Gas of this sort is extensively used for annealing cold rolled strip in radiant-tube, box-annealing and bell-annealing furnaces in conjunction with inner covers which surround the charge of steel and contain the protective atmosphere. Although nitrogen and hydrogen-nitrogen atmospheres are widely employed for tin-plate annealing today, this changeover is recent and a high percentage of tin plate is still annealed in exothermic atmosphere. Annealing and spheroidizing cold drawn wire and rod, as well as bar stock, is satisfactorily accomplished in exothermic atmosphere; most of this work is done in box or bell-annealing furnaces. Cold drawn tubing is generally annealed in exothermic atmosphere in a continuous roller-hearth type furnace, heated either electrically or with radiant tubes (Fig. 3).

Another successful application is continuous annealing of tableware blanks of nickel silver (65% Cu, 18% Ni, 17% Zn), at 1300° F. Annealed blanks must be absolutely clean and scale-free. A complication in this process is the tendency for zinc to volatilize. A low dew point prevents oxidation, and although the water gas reaction tends to raise the dew point in the furnace, continuous introduction of dry gas at correct locations in the furnace counteracts this and flushes the gas toward the charge end of the furnace. This also prevents any zinc vapor from contaminating the cooling zone atmosphere or depositing on the annealed work.

Final annealing of copper tubing is being done in a furnace similar to Fig. 3. Freshly introduced exothermic atmosphere (dew point 40° F.) blankets the heating zone and is rapidly recirculated in the cooling zones which eliminates the possibility of water stains on the finished product. The coils of tubing are purged with the same atmosphere, dried to −40° F. dew point and then sealed, thus maintaining the inner walls clean and bright.

These are but a few of many applications.

Endothermic Atmosphere

*By RALPH J. PERRINE**

Temperature variation within the catalytic mass and other factors affecting the composition of the prepared gas and its stability after entering the heat treatment furnace.

THE ENDOTHERMIC atmosphere generator, as shown in Fig. 1, consists essentially of two accurate metering devices for the air and the hydrocarbon gas, a gas pump for introducing the mixture into the reactor, a retort filled with catalyst, and a chamber for heating the retort. In most cases the gas on exit is rapidly cooled below a critical temperature range to minimize deposition of carbon from the unreacted hydrocarbon (methane). Carbon monoxide is also unstable in this temperature range and may add to the difficulties by sooting and increasing the undesirable CO_2 and H_2O contents of the prepared atmosphere.

The process is usually referred to as an "endothermic reaction", since it requires external

*Experimental Department, Electric Furnace Co., Salem, Ohio.

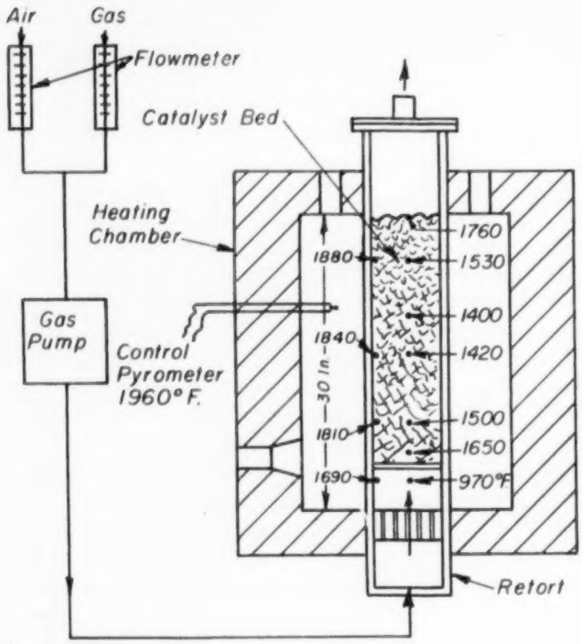


Fig. 1 – Flow Diagram for Endothermic Generators. Temperatures at retort wall and center are for flow of 1500 cu.ft. gas per hr., mixture of 2.6 parts air to 1.0 natural gas. Exit gas analysis: 0.4% CO_2, no O_2, 39.0% H_2, 19.6% CO, 0.4% CH_4, 40.6% N_2, 38.5° F. dew point

heating of the retort to maintain a satisfactory reaction temperature. To prepare a gas which will be stable (in the sense of acting in a predictable manner in the heat treating furnace) the importance of reaching equilibrium conditions cannot be overemphasized. Even though some heat is liberated in the partial combustion of the air-fuel mixture fed to the retort, considerable heat is absorbed before the hot gas leaves the generating unit. Hence the logic of calling it "endothermic gas". The temperatures noted in Fig. 1 show evidence of an exothermic reaction in the early stage; there is a peak in the central temperature considerably above the catalyst-supporting hearth. At this level the amounts of CO_2 and H_2O are a maximum as a result of the partial combustion of the air-gas mixture. This temperature peak appears at higher elevation levels for higher flows, and lowers toward the bottom of the catalyst bed at restricted flows of air-gas mixture.

After reaching this peak, the temperature drops to approximately 1400° F., indicating that in this zone an endothermic reaction is taking place. Then, as the gas passes along, its temperature increases throughout the remaining length of the reaction chamber, and the CO_2 and H_2O are reduced to their exit value.

Under the operating conditions shown in Fig. 1 and its caption the exit temperature was 1760° F. for a total flow of 1500 cu.ft. per hr., 200° less than the control temperature of the generator heating chamber.

It is also evident that there is a temperature gradient from outside to center of the catalyst bed. Heat is transferred through the retort wall rapidly enough to supply the requirements of the reacting gas, and consequently the temperature near the wall gradually increases along the length of the retort. Temperature measurements at the center of the catalyst bed, however, drop after the early exothermic reaction, due to the poor rate of heat transfer through the catalyst. This accounts for the temperature gradient, wall to center, and influences the exit temperature of the atmosphere and its quality or composition.

The quality of the prepared atmosphere depends largely upon four* factors which will be discussed in order:

1. Air-fuel ratio.
2. Temperature.
3. Detention time.
4. Activity of the catalyst.

Air-Fuel Ratio – The relationship between composition of the generated atmosphere and various air-fuel ratios at the input is shown in Fig. 2. An air-fuel ratio of 2.598 to 1 will produce endothermic gas containing less than 0.1% CO_2 and a dew point of −15° C. (5° F.). The unreacted methane is less than 0.4%. By increasing

Table I – CO_2 Values and Corresponding Dew Points

Constituent	Atmosphere		
	2.6 Ratio	2.65 Ratio	2.75 Ratio
CO_2	0.2	0.4	0.6
O_2	0.0	0.0	0.0
H_2	39.0	38.6	38.4
CO	19.4	18.5	17.4
CH	0.4	0.4	0.3
Dew point °C.	−12.5	−4.0	3.0
°F.	9	24.8	37.4

*W. P. Benter, Jr., of Timken Roller Bearing Co. suggested that humidity (water content) of the air going into the generator is a fifth important factor.

the ratio from 2.598 to 2.625 to 1, the CO_2 increases to 0.35% while the dew point reaches a value of −7° C. (19° F.).

Since such a slight change in the input ratio results in a marked change in the constituents of the effluent, the importance of ratio control must be emphasized. Poor ratio control may easily defeat a heat treatment program.

Figure 2 shows large changes in moisture content and relatively small changes in the other constituents. Therefore, for control purposes, the dew point allows more latitude than measuring the CO_2 in the gas, however accurately. For a spread of 0.4% in CO_2 the dew point changes from −12.5 to 3° C. (9 to 37° F), or a spread of 15.5° C. (28° F.). Table I shows corresponding gas analysis, operating conditions other than air-gas ratio remaining constant.

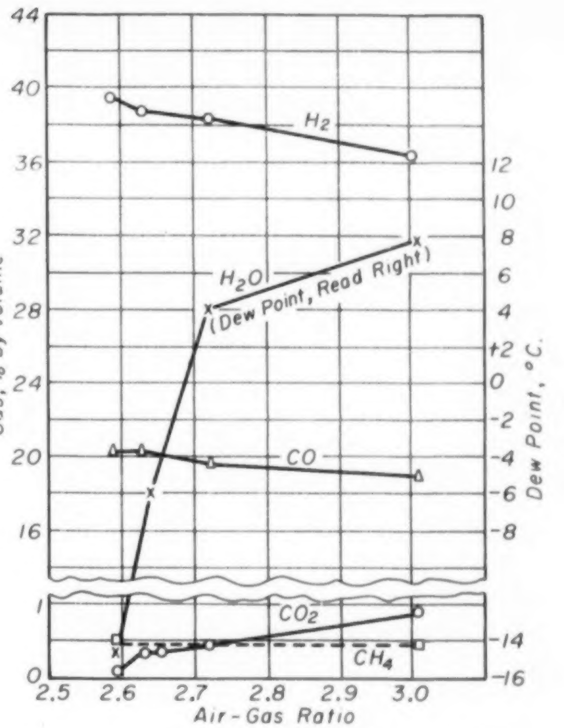


Fig. 2 – Curves Showing How Analysis and Moisture Content (Dew Point) of Endothermic Gas Vary With the Air-Gas Ratio Fed to the Generator

Temperature – The speed of any reaction increases with temperature. From this standpoint high generator temperatures are favored within the limits of good design. From a practical standpoint there is little to be gained above 1850 to 1900° F., as is borne out by gas analyses, dew-point readings and carbon potential tests of gas from generators operating at 1600 to 2200° F. Reference to Table II gives the comparison values. The gas analyses show little, if any, change above 1800° F. – at least within the accuracy of the analytical methods. The dew points are also about the same, and these can be determined with greater accuracy. Carbon potential values (amount of carbon absorbed by low-carbon steel shims during heat treatment) show no definite trend.

Since no benefit was indicated at higher generator temperatures, the problem merits further analysis from a theoretical point of view. For any assumed air-fuel ratio we can calculate the amount of each constituent entering into the reaction, and the expected composition of effluent gas in equilibrium at each specific temperature can be computed.*

Results of several hypothetical situations are shown in Table III. The natural gas was assumed to analyze 84.6% CH_4, 13.4% C_2H_6 and 2.0% N_2. In the column heads 30% P.C. means that the above fuel is reacted with 30% as much air as needed for perfect combustion.

A comparison of these computed values with performance figures in Table II shows higher CO and lower H_2, and no methane. Since there is always some unreacted methane in endothermic gas, its presence results in higher dew points, since the *reacting* ratio is leaner than the ratio indicated by the flow meters. Referring to the column in Table III for 28% air for perfect combustion, 1900° F. and complete reaction of CH_4, 1.37% of water should result (a dew point of 54° F.). For 0.3% unreacted CH_4 in the prepared atmosphere (6th column in Table III) the water content has increased to 1.61% (dew point 58° F.).

From a practical point of view the only significance of the above calculations is to show that

*EDITOR'S NOTE – Mr. Perrine's paper contained the arithmetic and algebra for figuring a particular problem, but it has been crowded out for lack of space. First compute the amounts of C, O_2, H_2, and N_2 in the input. Then let *a* be the amount of CO_2 in the effluent gases, *b* the CO, *c* the H_2O and *d* the H_2. (The nitrogen, of course, goes through unchanged.) The carbon is split between CO_2 and CO; the hydrogen between H_2O and H_2, so two equations can be written to show that fact. The oxygen is split between CO, CO_2 and H_2O, and here is a third equation. The fourth equation necessary to solve for the four unknowns concerns the equilibrium factor for the water gas reaction:

$$K = \frac{ad}{bc} = 0.53 \text{ (at 1900° F.)}.$$

Table II – Effect of Temperature on Endothermic Atmosphere

	1600° F.	1800° F.	2000° F.	2200° F.
Generator gas				
CO_2	0.7	0.2	0.3	0.25
O_2	0.0	0.0	0.0	0.0
H_2	37.6	39.2	39.3	39.8
CO	18.2	19.8	19.8	19.6
CH_4	1.0	0.2	0.2	0.2
Dew point	50° F.	35° F.	39° F.	36° F.
Gas in furnace				
CO_2	0.3	0.4	0.35	0.3
O_2	0.0	0.0	0.0	9.0
H_2	40.2	40.3	40.2	40.7
CO	18.8	19.2	19.4	19.3
CH_4	0.5	0.3	0.3	0.25
Dew point	38° F.	40° F.	37° F.	36° F.
C potential*	0.50	0.57	0.60	0.62

*Analysis of 0.10 C and 1.3 C steel shims after exposure to furnace atmosphere.

the air-fuel ratio is more effective than high generator temperature in lowering the CO_2 and dew point of the prepared gas. By enriching the fuel input ratio (30 to 28% air for perfect combustion) the CO_2 and moisture was cut in half, while an increase in temperature of 300°, from 1900 to 2200° F., resulted in a very slight decrease in CO_2 and an actual increase in moisture – at least for theoretical equilibrium. Another important aspect shown by the last two columns in the table is the increase in water vapor when unreacted methane is present in the generated atmosphere. This can be partially compensated for by operating at a slightly richer ratio.

However, the air-fuel ratios cannot be promiscuously enriched to obtain lower CO_2 and dew points without expecting operating difficulties. When the relative amount of fuel increases, the mixture is prone to throw soot down in the catalyst bed. This will eventually build up sufficient back pressure to affect the flow settings.

Table III – Calculated Analyses

Gas	30% P.C.		28% Air for Perfect Combustion			
	1900° F.	2200° F.	1900° F.	2200° F.	1900° F.*	2200° F.†
CO_2	0.7%	0.6%	0.4%	0.3%	0.4%	0.35%
O_2	0.0	0.0	0.0	0.0	0.0	0.0
H_2	35.5	35.4	37.3	37.3	36.8	37.0
CO	19.5	19.7	20.2	20.3	20.0	20.2
CH_4	0.0	0.0	0.0	0.0	0.3	0.15
H_2O	2.5	2.65	1.37	1.45	1.61	1.55
D.P.	70° F.	72° F.	54° F.	55° F.	58° F.	57° F.

*Assuming 1.6% CH_4 not reacting. †Assuming 0.8% CH_4 not reacting.

When the ratio of air to gas approaches the theoretical for zero H_2O and CO_2 in the products, the fuel should be increased with caution.

Detention Time – Another important factor in endothermic atmosphere generation is the time the gas takes to pass through the catalyst column. For any temperature a generated atmosphere will be almost completely reacted if sufficient time is allowed. It should be obvious that the analysis of the gas mixture changes until a definite composition, which is characteristic of the temperature, is attained.

Even though an atmosphere is completely reacted in the generator, there is no assurance that on reheating there will be no further reacting in the heat treating furnace. Any mixture of gases containing CO_2, H_2O, CO, H_2 and CH_4 will react to satisfy a new set of equilibrium conditions, such as temperature, contaminents carried in with the product, or infiltration of air. However, under good operating practice and atmosphere control, the tendency for such change can be minimized.

Figure 3 shows what might be expected when an endothermic atmosphere is passed through two generators in series so as to reach equilibrium, then dried to a dew point of −45° C. (−49° F.), about 7% of methane added, and then passed through an alloy tube heated to various temperatures. At 600° F. there was a moderate increase in dew point; the dew point increased rapidly to +9° C. (48° F.) when heated to 900° F., and gradually decreased to −20° C. (−4° F.) as the gas mixture was heated more and more, finally reaching 1900° F. An element balance, based on gas analyses, showed a loss of carbon (from 25.7 to 23.2%), oxygen (from 17.6 to 17.1%) and hydrogen (from 41.9% to 40.9%). Carbon monoxide, being unstable in these temperature ranges, cracked and deposited carbon, freeing oxygen for recombining with more CO_2 and H_2 to increase the CO_2 and H_2O content of the atmosphere. The total loss isn't all accounted for in this manner, but the trend is significant.

The same trend, but by no means so pronounced, was observed in a production furnace. Both the CO_2 and the H_2O in the furnace gas analysis dropped considerably as the furnace tem-

perature was raised. Thus: 1.1% CO_2 and 67° F. dew point at 1000° F., and 0.60% CO_2 and 48° F. dew point at 1600° F.

Table IV – Effect of Catalyst

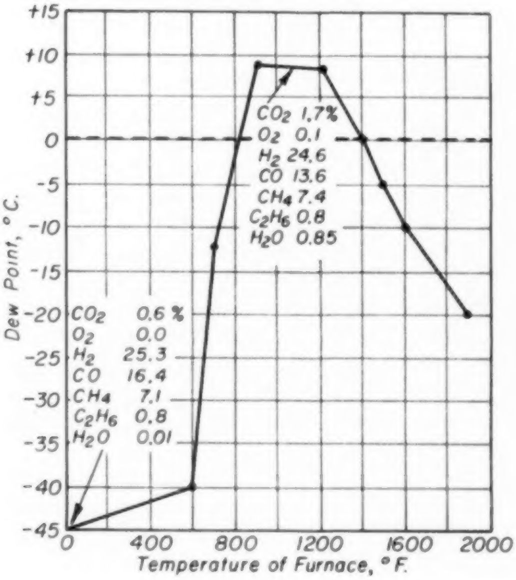
Analysis	No Catalyst	Catalyst
CO_2	2.0%	0.0%
O_2	0.0	0.0
H_2	27.9	39.6
CO	15.7	20.3
CH_4	7.1	0.9
N_2	47.3	39.2

Catalyst – The last factor under consideration in the generation of endothermic atmosphere is the activity of the catalyst. A catalyst is powerless to change the K value at equilibrium, but it does reduce the time required to attain equilibrium.

Table IV shows analyses after the same gas-air mixture (2.57 parts of air to 1.0 of gas) has passed through a retort at 1950° F. at the rate of 550 cu.ft. per hr. In one test the retort was clear; in the other it was filled with an appropriate catalyst. The catalyst decreased the CO_2 from 2.0% to zero and the methane from 7.1 to 0.9%, resulting in a satisfactory atmosphere. Without its aid the detention time would have to be increased several times; this would require a larger unit or reduced capacity.

Sometimes, even though a catalyst is present, little if any benefit is obtained. In other words, the catalyst isn't very active. Its activity is affected appreciably by extremely small amounts of foreign substances ("poisons") which may react with the catalyst or blanket its surface, preventing gas contact. Soot is an example of the latter case.

Fig. 3 – Change in Gas as Measured by Dew Point as It Is Reheated in Empty Furnace to Temperatures Shown



If the catalyst is poisoned or blanketed, the CO_2 and CH_4 of the effluent increase, with a corresponding increase in its dew point. If the air-gas mixture is enriched to compensate for the increase in CO_2 and H_2O, the condition is only aggravated. Plugging of the unit with soot is a certainty.

From a practical standpoint, it is desirable to operate the generator so its output contains a trace of CO_2 or a dew point of −7 to −4° C. (19 to 25° F.). This will insure minimum downtime and maintenance. For carburizing operations, 0.2 to 3% CO_2 and −9 to −7° C. (15 to 20° F.) dew point is a satisfactory carrier gas. In most reheating for hardening the CO_2 may be carried at a higher level – say, 0.5 to 0.6% and a dew point of 10 to 16° C. (50 to 60° F.).

In atmospheres for carbon correction the control is more critical. It must be adjusted to give the desired carbon head or carburizing potential. When treating high-carbon steels, it may be necessary to operate at lower CO_2 and dew points than is considered good commercial operating practice. Higher values may be used with methane additions, but the addition of a hydrocarbon makes it very difficult to control carburizing action within narrow limits. There is a wide band of carbon pressures for a given dew point. Much closer control can be had by using a straight endothermic atmosphere tailored for the job.

Ralph J. Perrine

Since graduating from University of Cincinnati with a degree in mechanical engineering, Mr. Perrine has been associated with the Electric Furnace Co. in the experimental department. Most of his time has been devoted to development of methods for atmosphere control and their practical application in industry.

Dry Nitrogen as a Base for Prepared Atmospheres

*By DONALD BEGGS**

Very dry atmospheres containing substantially nothing but nitrogen and hydrogen (except perhaps a little carbon monoxide on occasion) have proven very useful for scale-free heating, for carrier gas, for inert atmosphere and for purging explosive mixtures. Methods of manufacture are outlined and commercial equipment illustrated.

In INDUSTRIAL furnaces, prepared atmospheres based on dry nitrogen are being applied widely. *Pure* dry nitrogen, by itself, has no practical utility, since it is completely inert to most materials and it would become oxidizing due to unavoidable contamination, however slight, by water vapor or oxygen inevitably entering an operating furnace. It is therefore necessary for the nitrogen to carry 1.0 to 2.0% of a reducing constituent such as H_2 or CO, the exact amount depending upon how the gas is prepared and upon its ultimate use.

Application – Nitrogen-base atmospheres have four general fields of application:

First, they are used as an inert protective atmosphere. One early large-scale application was in about 1940 for truly scale-free heating of steel for forging propeller blades.

A second field of application is as a carrier gas for some reducing constituent which is increased to where it is mildly reactive. One present-day example is in annealing of tin-plate stock where the nitrogen contains 5 to 15% of H_2 and the combination becomes a reactive, carbon-free, deoxidizing gas which gives an improved steel surface for tinning.

Third, is their use as a stable carrier to which other gases are added to achieve a specific reaction. An example is the commercial carbon restoration of medium-carbon steel stock, where a predetermined carbon potential of the atmosphere is maintained by an enriching gas (such as endothermic gas) or natural gas.

*Assistant Director of Research, Surface Combustion Corp., Toledo, Ohio.

The fourth general field is for the purging of furnaces which normally contain highly explosive atmospheres such as hydrogen – for example, the large continuous annealing furnaces for galvanizing stock. Nitrogen-base gas can quickly purge such furnaces in an emergency, as well as replace the air during normal start-up or the hydrogen atmosphere prior to normal shut-down.

Source – Dry nitrogen-base atmospheres are now commercially prepared from three sources:

First and most widely used is a fuel gas, usually natural gas, burned with air and the CO_2 and H_2O then removed.

Second is the catalytic reaction of anhydrous ammonia with air.

The third source is byproduct nitrogen from an oxygen plant (or bottled nitrogen). In any of these residual oxygen is catalytically reacted with hydrogen, and the water vapor removed.

As to cost: Relatively speaking, fuel gas plus air is a cheap source of nitrogen-base atmospheres with a reasonable capital cost of equipment. Anhydrous ammonia plus air is a considerably more expensive source, but the equipment is cheaper, especially in small units. (See Mr. Ogle's figures, p. 100.) Byproduct nitrogen can be a very cheap source, with low investment in atmosphere preparation equipment, but it is limited geographically to a close proximity to the source of the nitrogen, except for small-scale use.

Methods of preparation are now reasonably well standardized. Although the equipment made by various manufacturers will differ in details, the following descriptions will generally apply.

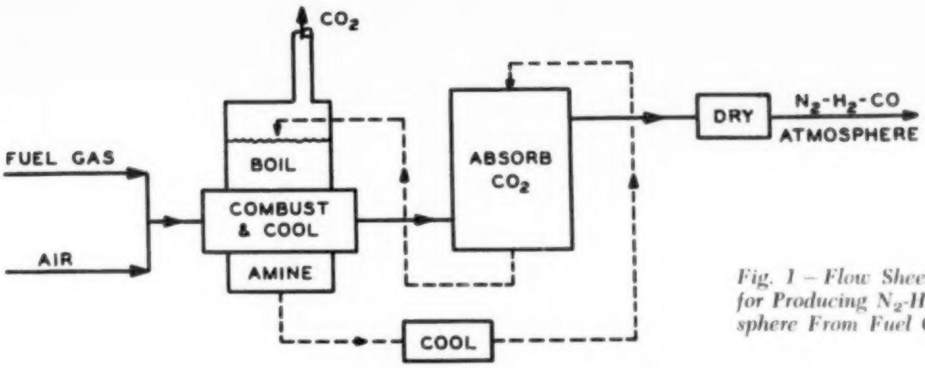


Fig. 1 – Flow Sheet of Process for Producing N_2-H_2-CO Atmosphere From Fuel Gas and Air

N_2-H_2-CO From Fuel Gas and Air

The atmosphere produced from fuel gas and air will contain both the reducing constituents H_2 and CO. Fuel is ordinarily natural gas (although desulphurized coke oven gas and propane are being used). A typical analysis of such an atmosphere is:

N_2 – 98.0 to 90.0% (adjustable)
H_2 – 1.0 to 5.2% (adjustable)
CO – 0.9 to 4.7% (adjustable)
CO_2 – 0.1% or less
CH_4 – trace
H_2O – Dew point 40° F.

In the preparation equipment as diagrammed in Fig. 1 and photographed in Fig. 2, the fuel gas is burned with a slight deficiency of air to produce the desired percentage of H_2 and CO in the resulting flue gas. The CO_2 is absorbed in a water solution of mono-ethanolamine (called amine or MEA, for short) and the water of combustion is removed by primary cooling to about 100° F., refrigeration to 40° F., and adsorption by alumina or other adsorbent to the desired low dew point.

An amine solution can efficiently absorb CO_2 at 100° F. and readily gives it up when boiled. The amine is circulated in a closed circuit which includes an absorber tower, a reboiler, and an indirect water cooler. In the earlier systems, reboiling was done with steam from an external source; today it is common practice to use the heat liberated from the original combustion of the fuel gas, no external heat source being required. Such atmosphere generators are small, highly efficient, "package" chemical plants.

This type of N_2-H_2-CO generator has been in commercial use for about 15 years. The capacity already installed in the metallurgical field is of the order of 500,000 cu.ft. per hr., in unit sizes up to 20,000 cu.ft. per hr.

When producing an atmosphere with 98% N_2, about 125 cu.ft. of natural gas and 1250 cu.ft. of air are required to produce 1000 cu.ft. of finished gas.

This atmosphere will not support combustion when the total H_2 plus CO is less than 4.0%, even when preheated to 1000° F. As such it is an excellent gas for purging. At conventional annealing temperatures of 1150 to 1300° F. for mild steel, the atmosphere is deoxidizing. It is moderately inert to carbon in steel over a wide temperature range. It will prevent oxidation of steel even at forging temperature. In the nonferrous field it is useful for batch annealing of certain bronzes and red brasses.

The N_2-H_2-CO atmosphere as usually produced is very low in both CO_2 and H_2O. Therefore there is a marked tendency for CO in a hot

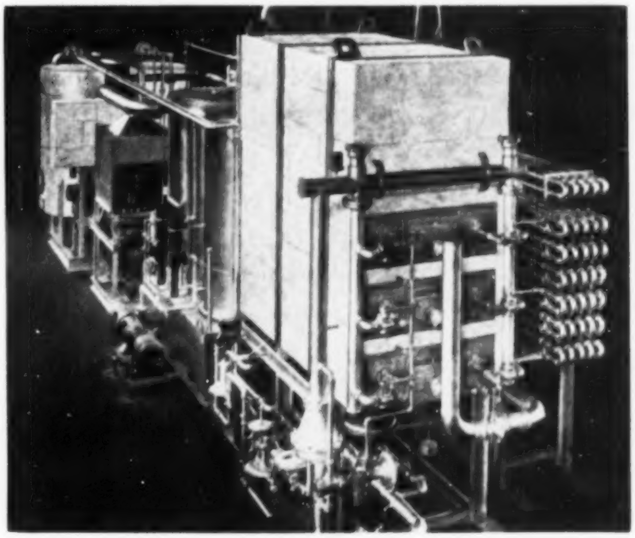


Fig. 2 – Generator for Making 15,000 Cu. Ft. per Hr. of N_2-H_2-CO

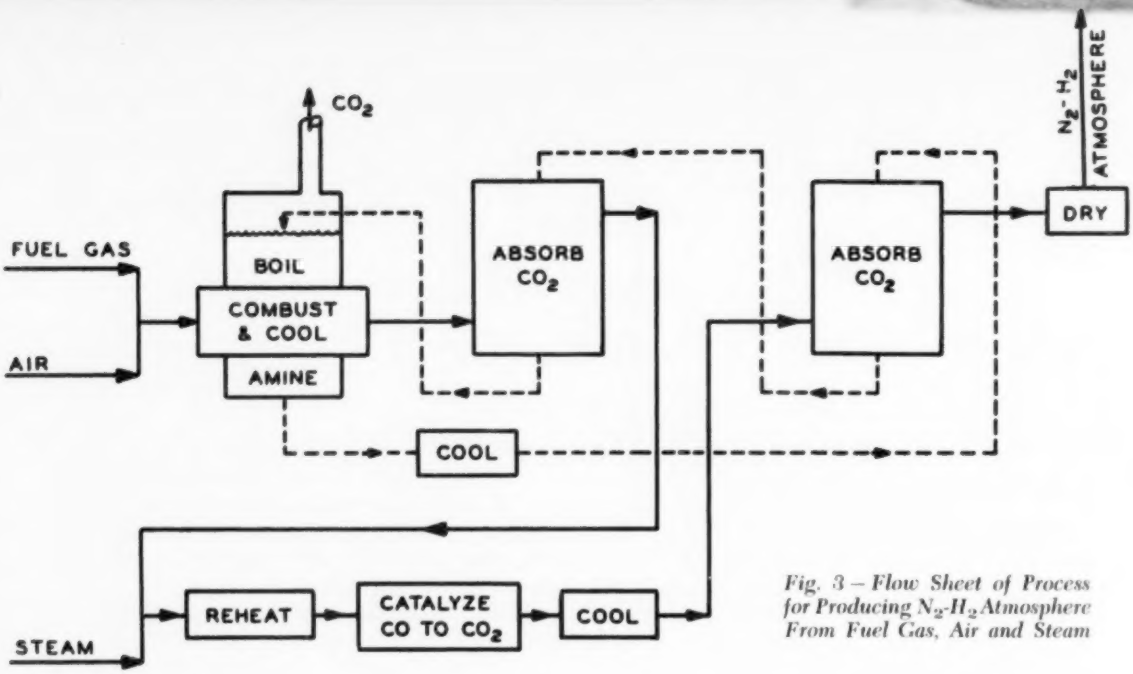


Fig. 3 – Flow Sheet of Process for Producing N_2-H_2 Atmosphere From Fuel Gas, Air and Steam

furnace to break down and form free carbon and CO_2. (The CO_2 then reacts with H_2 to form H_2O and CO.) The net result is the production of small amounts of soot and an appreciable rise in dew point. This action is particularly noticeable with the richer analyses at intermediate temperatures (800 to 1500° F.). It may be noted that a −40° F. dew point represents only 0.015% H_2O by volume, and very little of the above reaction is necessary to raise the dew point appreciably.

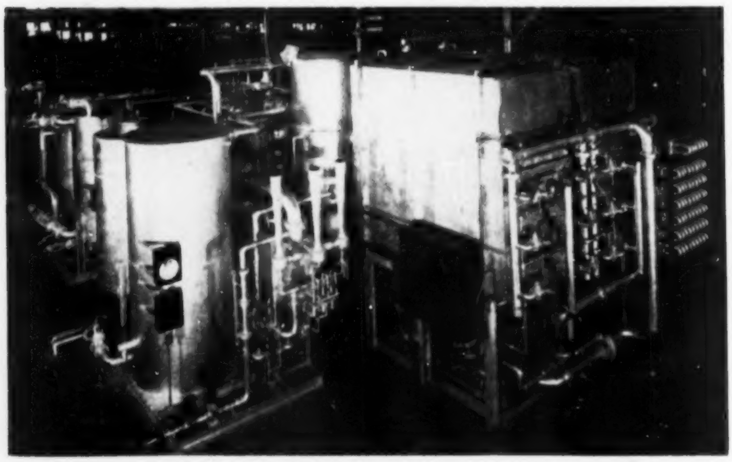
N_2-H_2 From Fuel Gas and Air

Presence of CO in the atmosphere just described is often objectionable – for example, in batch annealing of tin-plate stock where a very clean metal surface is desired after annealing. For these applications the CO can be substantially removed, resulting in typical analyses within the following limits:

N_2 – 98.0 to 85.0% (adjustable)
H_2 – 1.8 to 14.8% (adjustable)
CO – 0.1% or less
CO_2 – 0.1% or less
CH_4 – trace
H_2O – Dew point −40° F.

As before, the fuel gas is incompletely burned to a flue gas which contains CO plus H_2 about equal to that amount of H_2 desired in the final atmosphere. The CO_2 is absorbed with amine. The gas now contains essentially N_2, H_2 and CO and is saturated with water at 100° F.; it is then reheated to about 700° F. with about half of its volume of steam from an external source and passed over a catalyst, commonly iron oxide, to promote the reaction $CO + H_2O \rightarrow CO_2 + H_2$. The original CO is thus converted into an equal volume of H_2. The gas is then cooled to 100° F., the CO_2 resulting from the CO conversion is absorbed in a second amine tower and dehydrated to its final dew point.

Fig. 4 – Typical N_2-H_2 Generator, 25,000 Cu.Ft. per Hr., Photographed Before Reaction Chambers Have Been Insulated



Like its predecessor, the N_2-H_2-CO generator, this

Fig. 5 – Flow Sheet for Production of N_2-H_2 Atmosphere From Ammonia and Air

N_2-H_2 generator is a small, very efficient, "package" chemical plant. Figure 3 illustrates the simplified flow sheet and Fig. 4 shows a typical N_2-H_2 generator of 25,000 cu.ft. per hr. capacity.

This type of N_2-H_2 atmosphere generator was introduced to the steel industry about five years ago and has been widely adopted. Many of the existing N_2-H_2-CO generators have been converted to N_2-H_2 generators by adding the steam reheater, catalyzer and second amine system. The present installed capacity is estimated to be in excess of 400,000 cu.ft. per hr., in unit sizes up to 25,000 cu.ft. per hr.

When producing 98% N_2 and 1.8% H_2, approximately 125 cu.ft. of natural gas, 1250 cu.ft. of air and 25 lb. of low-pressure steam are required to produce 1000 cu.ft. of finished gas. For 85% N_2 and 14.8% H_2 the above figures are 135 cu.ft. of gas, 1080 cu.ft. of air and 25 lb. of steam.

This N_2-H_2 atmosphere is an excellent purge gas when the hydrogen is less than 4.0%; and in some places it might be preferable to N_2-H_2-CO for this purpose because of its substantial freedom from dangerous CO. Today, it is being widely used as the deoxidizing atmosphere for both batch and continuous annealing of tin-plate stock, with hydrogen as high as 15%, wherein it is both deoxidizing and slightly decarburizing. It is also being used commercially as the carrier gas for dissociated ammonia and small amounts of chlorine to effect a gaseous pickling of galvanizing stock. It is an economical carrier gas for higher hydrogen atmospheres in large continuous furnaces. When used alone as an atmosphere at high temperature, its dew point will rise somewhat due to re-forming of very small amounts of CO, but not at all to the extent inherent in a N_2-H_2-CO atmosphere.

N_2-H_2 From Ammonia and Air

In heat treating operations where even small amounts of CO and CO_2 or traces of CH_4 are objectionable, anhydrous ammonia is often used as the source of a high-purity N_2-H_2 atmosphere. (This is not to be confused with cracked or dissociated ammonia, as described in the next paper.) An example is hardening high-carbon steel razor-blade stock where control of surface carbon is both essential and difficult. Such atmospheres will analyze:

N_2 – 99.5 to 60% (adjustable)
H_2 – 0.5 to 40% (adjustable)
H_2O – Dew point –40° F., or considerably lower

As shown in Fig. 5, anhydrous ammonia (NH_3) is vaporized and mixed with air in a controlled ratio. The mixture is passed over a catalyst which efficiently promotes the reaction

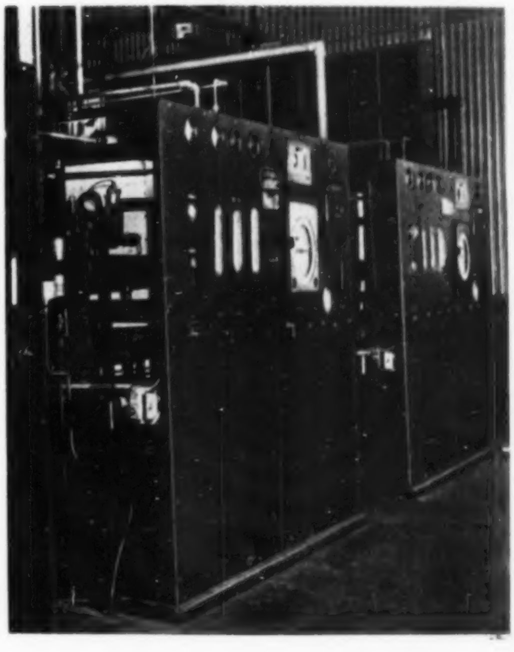
$$4NH_3 + 3O_2 \rightarrow 2N_2 + 6H_2O + \text{heat}$$

The remainder of the ammonia dissociates into nitrogen and hydrogen, which absorbs less heat than liberated in the oxidation. The resultant gas is then cooled and dehydrated to final dew point.

The ratio of ammonia to air is controlled to give the desired hydrogen in the atmosphere, as shown in Fig. 1 of Mr. Ogle's paper, p. 100. To insure the absence of free oxygen, there must always be some excess of ammonia.

This type of atmosphere generator is a com-

Fig. 6 – Two N_2-H_2 Generator Units Behind Their Control Boards. Courtesy M. M. Waller of Baker & Co., Inc., who also furnished some of the information in this paper



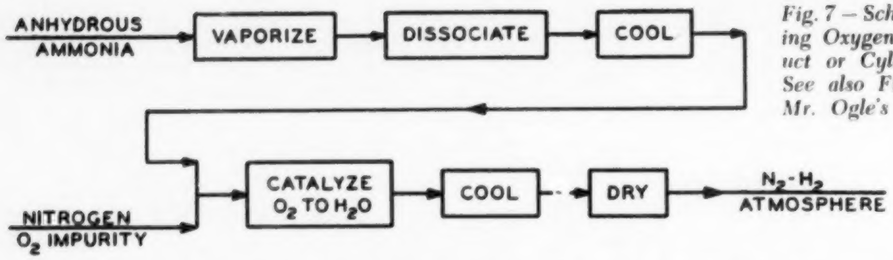


Fig. 7 – Scheme for Removing Oxygen From Byproduct or Cylinder Nitrogen. See also Fig. 2 and 3 of Mr. Ogle's paper, p. 100

paratively simple and compact unit. (Fig. 6). At present the installed capacity in the metallurgical field is about 150,000 cu.ft. per hr. in unit sizes up to 10,000 cu.ft. per hr. Quite small units are found in many laboratories.

When producing an atmosphere of 99.5% N_2 and 0.5% H_2, approximately 300 cu.ft. of ammonia and 1070 cu.ft. of air are required to produce 1000 cu.ft. of finished gas. When producing 70% N_2 and 30% H_2, the above figures are 385 cu.ft. of ammonia and 640 cu.ft. of air.

This atmosphere is very stable when heated by itself in a furnace, there being no constituents which will interact to produce water vapor and thus raise the dew point. Its "carbon potential" is zero – in fact, to avoid noticeable decarburization of steel the dew point must be considerably below −40° F. For specialties such as razor-blade stock, stainless steels and certain nonferrous alloys, this pure atmosphere when dehydrated to very low dew point will effectively preserve the surface during heat treatment. In large furnaces which contain considerable tonnages of steel under heat, appreciable quantities of CO and other gases are usually evolved from the steel; the resulting contamination tends to minimize the importance of an initial high purity, unless very high flow rates are maintained.

An alternate method of producing this atmosphere, but with a much lower maximum hydrogen, is to dissociate ammonia in conventional fashion, incompletely burn the dissociated ammonia with air in a simple combustion chamber, and then dehydrate to final dew point. This procedure is being followed in some plants where dissociated ammonia is available for other processes and which also require a high-nitrogen gas.

N_2-H_2 From Byproduct Nitrogen

Where byproduct nitrogen of relatively low purity is available from an oxygen plant (or even nitrogen of higher purity if economics are in a reasonable bracket) a N_2-H_2 atmosphere is being commercially produced by reacting the residual oxygen with hydrogen gas. An example is in a steel mill located alongside an oxygen plant; the atmosphere is used for annealing tin-plate stock. When nitrogen has oxygen as the only active impurity, the analysis and characteristics of the atmosphere produced from it are the same as have just been described, except that hydrogen is generally at a lower maximum value.

In preparation, the nitrogen is generally admixed with dissociated ammonia and passed over a catalyst which promotes the combination of oxygen with hydrogen at room temperature. Subsequently the gas is dehydrated to final dew point. The simplified flow sheet is shown in Fig. 7.

If the oxygen in the original nitrogen varies over a considerable range, it is necessary to guard against free oxygen in the prepared atmosphere and against overheating the catalyst.

This type of catalytic reaction is widely used in laboratories where cylinder nitrogen is mixed with cylinder hydrogen and the residual oxygen usually present in both gases reacted to moisture. With subsequent dehydration, a high-purity N_2-H_2 atmosphere, from, say, 99.5% N_2 to 99.5% H_2 can be produced.

Donald Beggs

Graduated as Electrical Engineer from Purdue, Don Beggs has been with Surface Combustion Corp. for nearly 20 years. Now assistant director of research, he has had a hand in many process developments, ranging from high-nitrogen atmospheres and their utilization (about which he contributes to the Industrial Heating Equipment Association's panel) to concentration of taconite, the low-grade iron ore (for which he received an award from the University of Minnesota).

Dissociated Ammonia

*By M. ROBERT OGLE**

A mixture of three parts hydrogen and one part nitrogen, dry – containing about 0.005% moisture by volume – is readily made in an inexpensive catalytic dissociator for liquid ammonia, and is useful for bright heat treatment of stainless and high-nickel alloys, for reducing oxides or decarburizing, or for a carrier gas for special purposes.

Dissociated ammonia in the last 20 years has become one of our widely used furnace atmospheres. As the name implies, it results from the cracking of ammonia into its constituent elements, and is a mixture of three parts of hydrogen and one part of nitrogen by volume.

Since anhydrous ammonia is made by the synthesis of hydrogen and nitrogen at high pressure according to the reaction

$3H_2 + N_2 \rightarrow 2NH_3$ (gas) + 21.9 kg-calories

the ammonia dissociator merely takes advantage of the fact that the reaction is reversible. Thus, two volumes of hot ammonia gas dissociates in the presence of a suitable catalyst into three volumes of hydrogen and one volume of nitrogen, with maximum water equivalent to a dew point of –50 to –60° F. (0.005% by volume).†

Dissociated ammonia, by virtue of its 75% H_2 and water-free analysis, is highly reducing and was at first an economical substitute for relatively costly hydrogen. The only contaminant is a small trace of undissociated ammonia which is of no consequence in the majority of applications. For the relatively few instances where the residual ammonia might be a problem, it is readily removed by passing the gas through an appropriate adsorber, or (if moisture can be tolerated) a simple water scrubber.

Uses – Dissociated ammonia is widely used in the following applications:

1. Heat treatment of stainless steels (bright annealing, hardening or brazing). Dissociated ammonia and pure dry hydrogen are two atmospheres which will consistently produce a truly bright surface when annealing austenitic and ferritic types of stainless steels.

2. Bright annealing of nickel alloys, copper and iron-silicon steels for electrical apparatus and transformers so as to obtain maximum electrical properties.

3. Bright copper brazing or silver brazing.

4. Sintering of powder metal compacts – particularly effective for brass, and excellent for iron and bronze.

5. Reduction annealing in production of iron powders and reduction of nickel and tungsten oxides.

6. Atomic hydrogen welding of medium and low-carbon steels and 18-8 types of stainless.

7. Controlling the formation of white layer in nitriding.

8. Degasification of various metal parts for electronic tubes.

9. As a source of hydrogen for the sodium hydride process of descaling.

10. As a source of hydrogen to remove oxygen from prepared atmospheres and to produce a reducing atmosphere free of carbonaceous constituents. A mixture of 10% hydrogen and 90% nitrogen has been widely applied in bright annealing and continuous galvanizing of steel strip. This has been discussed in some detail by Donald Beggs in the paper just preceding this one.

Dissociated ammonia, due to its high hydrogen content, is highly combustible, and adequate precautions as recommended by manufacturers of equipment should be maintained at all times. (See also the data sheet on p. 112-B.)

Cost of dissociated ammonia depends largely on the cost of the liquid anhydrous ammonia

*Sales Engineer, Drever Co., Philadelphia.

†In the discussion it was emphasized that *very* dry gas is obtainable in this way without use of costly drying equipment – a matter of special interest to the user of relatively small amounts of prepared atmospheres.

from which it is prepared.

Ammonia is available generally in cylinders containing 150 lb. of gas costing approximately 18½ c. per lb. delivered, and in tank car lots of 52,000 lb. costing approximately 5 c. per lb. delivered. In a number of areas it is also delivered by tank truck (3000 to 4000 lb.) at approximately 12 c. per lb.

The cylinders are returnable, but otherwise the user must provide his own storage facilities.

One pound of ammonia at 70° F. and one atmosphere pressure occupies approximately 22.5 cu.ft. Since the volume doubles upon dissociation, 1 lb. of ammonia (NH_3) produces about 45 cu.ft. of mixed hydrogen and nitrogen. Approximately 22.2 lb. of anhydrous ammonia, therefore, is required to produce 1000 cu.ft. of dissociated ammonia (measured at standard conditions of temperature and pressure).

The costs of ammonia to produce 1000 cu.ft. of dissociated ammonia are, therefore, \$4.11, \$2.66 and \$1.11, depending on the delivered price. Electric energy for heating is the other direct cost (although some gas-fired ammonia dissociators have been built). An average of 17 kw-hr. is required to produce 1000 cu.ft. of dissociated ammonia. This includes radiation losses. Using 1 c. per kw-hr. as an average cost, 17 c. must be added to the figures given above. Thus the total direct cost to produce 1000 cu.ft. of dissociated ammonia is \$4.28 for cylinder ammonia, \$2.83 for tank truck, and \$1.28 for tank car.

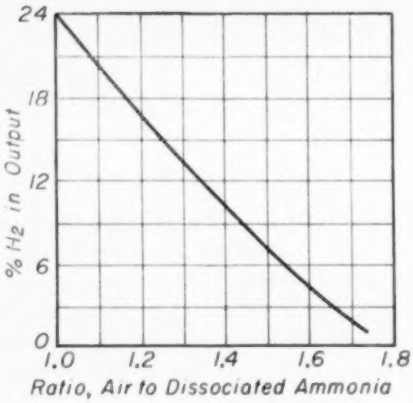


Fig. 1 – Hydrogen in Dissociated Ammonia Burned With Varying Amounts of Air

Comparing the above with the cost of hydrogen, which averages \$8 to \$12 per 1000 cu.ft. in most localities, the economics of dissociated ammonia are readily apparent. If, on the average, 50 cu.ft. per hr. of atmosphere or more is consumed, the installation of an ammonia dissociator should be economical. It would also eliminate the handling of many hydrogen cylinders; one

Fig. 2 – Flow Diagram of Typical System for Dissociated Ammonia Atmosphere

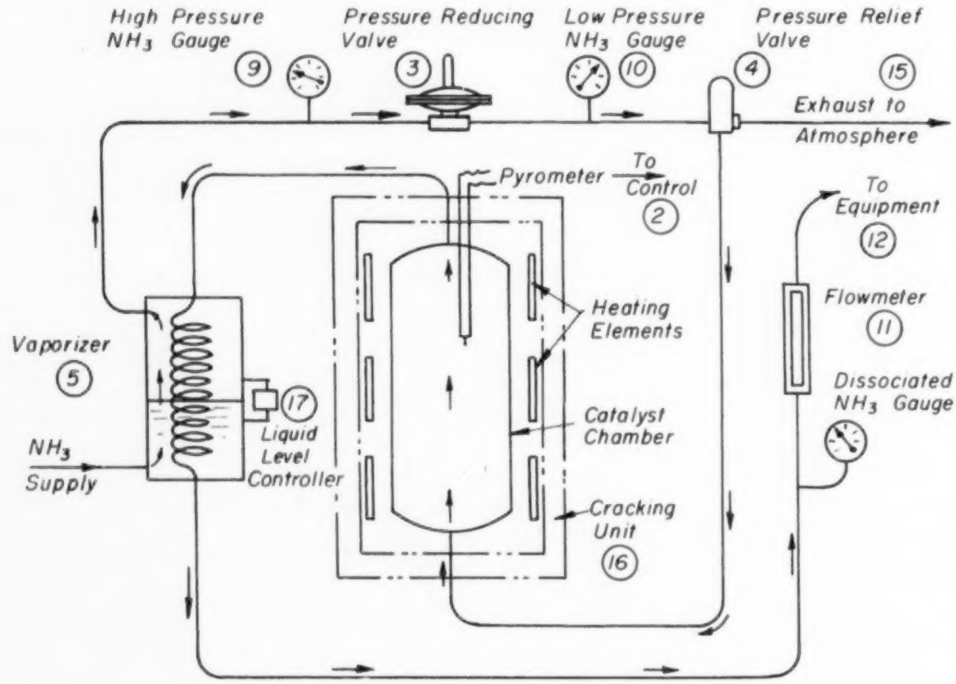


Fig. 3 – Dissociator Unit and Control Board

150-lb. cylinder of anhydrous ammonia represents approximately 7750 cu.ft. of dissociated ammonia and a like quantity of hydrogen would be contained in 39 heavy cylinders, all of which must be transported, handled, connected, disconnected and returned.

If atmosphere requirements are as much as 500 cu.ft. per hr. continuously (roughly 1,500,000 cu.ft. per year), the cost of installing facilities for handling tank car quantities can be justified.

Mr. Beggs has also described (p. 94) the useful method of producing nitrogen gas, free of carbon-bearing contaminents, namely, by burning dissociated ammonia with air in a conventional exothermic type generator. (The resultant atmosphere costs more per cu.ft. than similar atmospheres produced by other methods, but in small installations this is offset by the low investment in equipment.) Theoretically perfect combustion to zero hydrogen requires 1.78 volumes of air to 1 of dissociated ammonia. By varying this ratio the hydrogen content can be controlled at will from approximately 24% at the upper limit to 0.5% at the lower limit, as shown by Fig. 1.

Equipment – A few words are now in order concerning the ammonia dissociator itself. It is a relatively simple piece of equipment. The basic flow diagram is shown in Fig. 2. The unit itself is very compact (Fig. 3).

It is general practice to draw liquid ammonia from the supply into the vaporizer. From there the gas at high pressure is reduced to less than 20 psi. (gage); thence through the catalyst chamber. This consists of a vessel made of heat resisting alloy containing a suitable catalyst, located in a refractory-lined furnace. It usually receives its heat by radiation from ribbon resistors mounted on the walls. The temperature is normally controlled between 1650 and 1750° F.

The hot dissociated ammonia leaves the catalyst chamber and passes through the heat exchanger, where its heat vaporizes the liquid ammonia, then through a flowmeter into distribution lines to the furnace or operating equipment.

A panel board holds pyrometer for controlling temperature, pressure gages and flowmeter.

Variations of the basic system outlined above include additional control features such as protection against over and under temperatures, low-pressure alarm, supplementary heating for the vaporizer and pressure relief valves.

The modern ammonia dissociator is quite different in appearance and operation from the first units developed during the mid-1930's. Continuous research and engineering development by furnace manufacturers have given us a fully automatic, trouble-free generator, producing one of the most versatile furnace atmospheres.

M. Robert Ogle

A Virginian by birth, but a Philadelphian by education and vocation, Robert Ogle has been with the Drever Co. since 1944 – first draftsman, then design engineer, then application engineer and now sales engineer – for the most part specializing in controlled atmospheres for heat treating.

Atmosphere Analysis and Control

By WAYNE L. BESSELMAN*

New equipment is now available for automatic and continuous analysis of furnace atmospheres, notably absorption of infrared radiation by CO_2, CO, CH_4 and NH_3 (separately), the magnetic oxygen analyzer, and the use of thermal conductivity for hydrogen.

SINCE THE composition of prepared atmospheres should be known with precision, a continuous and instantaneous record of this knowledge is most important if the equipment is to produce a high-quality metallurgical product with economy and safety. Invention of new gas analysis equipment by instrument manufacturers in recent years now enables this to be done.

For example, infrared gas analyzers can directly measure and continuously record CO_2, CO and CH_4 with accuracy previously unobtainable. The infrared principle embraces two fundamentals: (*a*) Each gas compound absorbs certain wave lengths of infrared radiation and no other, and (*b*) the amount of radiation absorbed is proportional to concentration of the gas compound.

With infrared equipment we can have full-scale instrument ranges of 0 to 0.08% for CO_2; 0 to 0.2% for CO and 0 to 0.1% for CH_4. The scale ranges normally used would be greater than this but these minimum values serve to emphasize the superiority to other forms of gas analysis.

The magnetic oxygen analyzer is another recent development with full range from 0 to 1.0% or greater as desired. It uses the paramagnetic property of oxygen – that is, its ability to be drawn with a magnetic field – and is accurate to $\pm$ 0.05% and a sensitivity of 0.01% when the range is 0 to 1%.

Exothermic and Prepared Nitrogen Atmospheres – When a generator has accurate CO and CO_2 analyzers, rapid and precise adjustments can be made. The continuous record insures that the constancy of output can be maintained either manually or automatically. Figure 1 illustrates the records obtained on a conventional exothermic generator with various carburetor settings (air-gas ratios as shown). Normally one or the other quantity would probably be measured – that component which was more important to the process. Note that the pointer is quite stable at each setting; in such cases automatic control would probably be unnecessary.

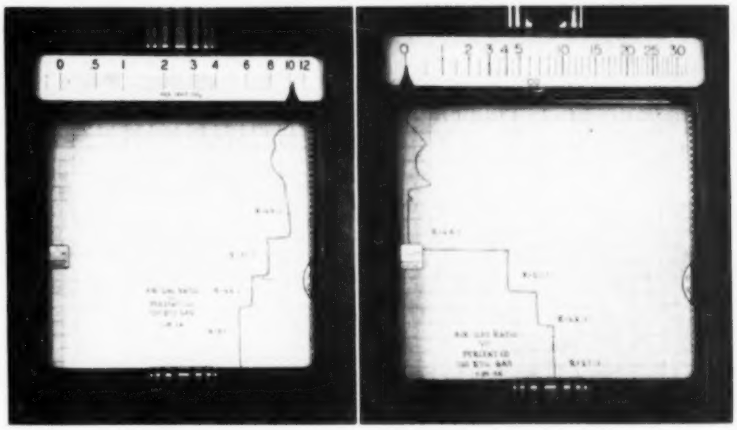
Analyzers such as these are particularly useful where the supply gas is variable, as might be true in a steel plant.† As a matter of fact, the deviations of the lines toward the top of each chart, where the ratio of air to gas was 6.4 : 1 were probably due to a change in gas supply, since it occurred from 5 to 7 P.M., at the peak of domestic cooking. (The record was extremely stable for the rest of the night.) Deviations of this type show the need for continuous recording and possibly for some alarm or automatic control, depending on the quality requirements of the particular application.

Where the exothermic gas is purified of CO_2 and H_2O to provide a high-nitrogen gas (with

*Leeds & Northrup Co., Philadelphia. The author is indebted to R. L. Davis II and C. Mariani, Jr., for assistance in obtaining the data. At the panel discussion at the National Metal Congress, held by the Industrial Heating Equipment Assoc., Mr. Besselman also made some very pertinent remarks about safety. These are contained in the Data Sheet, p. 112-B, in such shape that they can be posted near sensitive equipment.

†In discussion, H. L. Halstead, assistant fuel engineer at Sparrows Point plant of Bethlehem Steel Co., said that the exothermic atmospheres are manufactured at Sparrows Point from sulphur-free coke oven gas, and include both rich and lean mixtures of fuel gas and air. "We do, in all instances, remove CO_2 from the combusted gas from lean mixtures, and convert CO to H_2 in several applications, thus making an atmosphere free from all carbonaceous gases. Dew points range from + 50° F. (produced by refrigeration of the gas stream) to −40° F. (produced by a combination of refrigeration and desiccation). In all instances percentages of either hydrogen, carbon dioxide, or oxygen are continuously recorded. In some operations, two or more of these gases are recorded; in others, their concentration is maintained constant by means of automatic control."

Fig. 1 – Simultaneous Records of CO_2 (Left) and CO (Right) in Exothermic Gas Made From 700-Btu. Fuel Gas. Air-Gas ratios were arbitrarily changed at intervals as follows (from the bottom up): 3.7 to 1, 4.4 to 1, 5.1 to 1, and 6.4 to 1. Variation in record toward top of chart represents variations in pressure, volume or composition of fuel gas during peak hours



a controlled amount of CO and H_2) a CO_2 analyzer will insure that CO_2 is completely removed. The purification unit* is normally designed for a certain rated throughput, and any overloading will mean CO_2 in the gas and consequent trouble in the furnace operation. It is frequently stated that the output gas will contain from 0.1 to 0.2% CO_2, but actually the residual is more on the order of 0.05% maximum. However, any irregularity in the flow of amine solution to the absorption tower, or in the gas throughput will increase the CO_2 and cause excessive decarburization in the heat treating furnace.

Figure 2 at left demonstrates the effect of excess throughput, and indicates quite clearly that a small overload on a generator will produce an active rather than an inactive gas. The effect of change in absorbent flow at rated gas input is also shown in Fig. 2 at right. Obviously, flow of reagent must be correct. A constant recording instrument on service such as this permits generators to be operated at their maximum throughput without fear of a CO_2 content dangerous to the metallurgical product. It likewise serves as a 24-hr. policeman on the operation of the entire equipment, including pumps, flows, concentration and cooling.

For many applications the purified exothermic gas (CO_2 and H_2O removed) is used with varying amounts of H_2 and CO. Hydrogen content may then be measured with thermal conductivity apparatus, since the CO_2 is removed to such a low value that it does not interfere. Simultaneous measurement of H_2 and CO at various air-gas ratios is shown in Fig. 3. A similar measurement could be made with a combustibles meter, but it would not separate the two components. These measurements are also of importance from the safety standpoint when the gases are used in the range between 400 and 1100° F. for bright drawing or tempering. The analyzer would then aid the operator to use the maximum amount of CO or H_2 to maintain the gas on the

*An amine or MEA scrubber, as described by Mr. Beggs on p. 95.

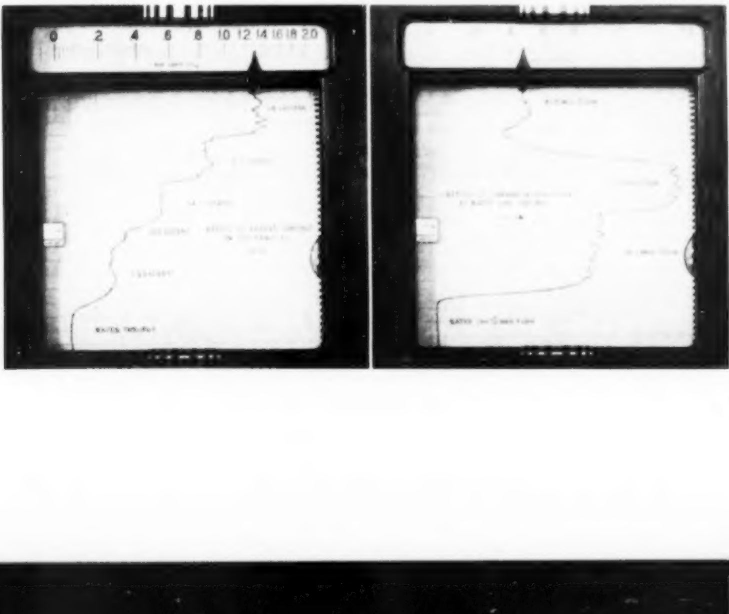


Fig. 2 – CO_2 "Speedomax" Charts Showing at Left How CO_2 Content of Exothermic Gas Increases as Generator Throughput Is Increased 7% Above Rating, 10%; 14%, 21% and 28%. At right is record showing effect of deficient flow of CO_2 absorber (MEA or amine) – 100%, 78%, 70% and 82% of correct amount

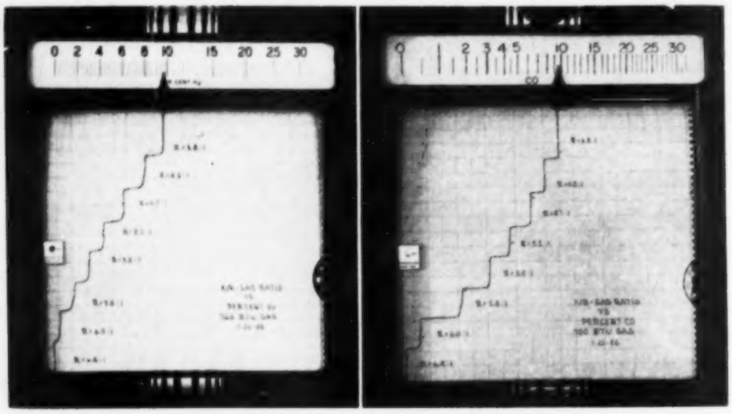


Fig. 3 – Parallel Graphs Showing Influence of Air-Gas Ratio on Hydrogen Content (Left) and Carbon Monoxide Content in Exothermic Gas. Ratio varies by steps, bottom to top, as follows: 6.4, 6.0, 5.8, 5.5, 5.2, 4.7, 4.3 and 3.8

reducing side, and still keep it nonexplosive.*

For many annealing jobs in a very lean nitrogen atmosphere, traces of oxygen may be present, and would oxidize the product.

Since the generated gas is produced primarily by combustion, the burner characteristic is most important. If air and gas are not intimately mixed, there is always the possibility of incomplete combustion. Small amounts of CO and H_2 do not necessarily indicate that the combustion is complete, and to be certain, a magnetic oxygen analyzer is suggested. It is rapid, accurate and is sensitive to 1% of full-scale range. Figure 4 shows such a record at various air-gas ratios for 700-Btu. gas.

This analyzer could also be used to measure the furnace gases, to spot leaks in the furnace or its seals. However, it cannot be used for atmospheres which are highly reducing or carburizing, because of interferences from high percentages of H_2, CO and CH_4.

The only remaining units on exothermic generators which should be checked for performance are the refrigerator and drying units. The drying unit can be monitored by dew-point apparatus of the indicating or recording type; the refrigerator by an indicating thermometer.

Endothermic Atmospheres – Output of these generators has long been gaged by the old-fashioned Orsat equipment. More recently the dew point has been used. (See Mr. Koebel's paper on p. 110 and Mr. Cullen's on p. 114.) If the CO, H_2 and N_2 contents are in equilibrium, the quality can be determined by measuring

Wayne L. Besselman

Wayne Besselman (graduate of Holy Cross College with post-graduate work at Massachusetts Institute of Technology and Temple University) has been with Leeds & Northrup Co. nearly 20 years. In that time he has invented several devices for controlling gas atmospheres. He is now in charge of development and production engineering on heat treating furnaces.

*Warren L. Grant of the plant engineering department of the propeller division of Curtiss-Wright (Caldwell, N. J.) commented that the infrared CO_2 analyzer has been a valuable aid for monitoring a "CO_2-free" atmosphere bone dry (−70° C. dew point), containing 11% H_2 and 8% CO. This controls the concentration, reactivation, and flow rate of the MEA solution used for stripping the CO_2 from the produced atmosphere. "We use a rich air-gas ratio, resulting in lower CO_2 from the generator, and operate the producer at only 80 to 90% of its rated capacity. We can then continually produce an atmosphere with 0.00 to 0.02% CO_2 as measured by the infrared CO_2 analyzer (range 0 to 1%).

"We also use the magnetic oxygen analyzer to insure that the oxygen content of purged retorts in stress-and-draw operations is below 1% for safety and 0.1% for quality. The oxygen analyzer permits the use of a flammable exothermic atmosphere for both purging, prior to loading the retort in the furnace, and operating wherein clean bright work is produced. Therefore, the need for changing generator ratios or using two sources of atmosphere (as would otherwise be necessary for safety) is eliminated."

Fig. 4 – Oxygen Analysis of Exothermic Gas, Measured Continuously by Magnetic Means, as It Varies With Various Air-Gas Ratios Entering Atmosphere Generator, Respectively, 6.4, 6.42, 6.45, 6.53, 6.60, 6.75, 6.85 and 7.63 (From Bottom to Top)

either H_2O, CO_2 or CH_4. This means that in addition to the use of dew point as a control, we can use infrared analyzers to measure and control accurately either CO_2 or CH_4. This provides a direct and continuous measurement with rapid response and high sensitivity.

Figure 5 shows charts measuring CO_2 and CH_4 in the output of a conventional endothermic generator. In this case the CO_2 was placed under full automatic control at 0.3% by operating a valve in the air supply line, and the right-hand record shows quite well the sensitivity and response. The rapid departures from the set point represent varying demands for gas as the furnace pressures changed when the doors were opened for each push of the work. They also show an inadequate air-gas ratio controller. Some of the "hash" can also be attributed to minor changes in the gas composition which resulted from the on-off control of catalyst temperature. The CH_4 record at left of Fig. 5 is more stable, primarily because instrument range was greater.

Such analyzers open a wide range of possibilities to those interested in metallurgical research involving atmospheres or generators. For example, one can continuously record the $CO:CO_2$ ratio or the $H_2:CH_4$ ratio and, in combination with a dew-point analyzer, the $H_2:H_2O$ ratio. Analyzers with multiple point recorders can also monitor several generators at the same time.

Dissociated Ammonia – Control of ammonia dissociators is usually no major problem. Dissociation is normally complete (or better than 99%) and if the residual ammonia is undesirable it can be removed by activated alumina. If necessary or desirable, the infrared analyzer can continuously record the undissociated NH_3. The full scale range can be as low as 0 to 1%, which would provide a high degree of accuracy and readability. This means that on critical applications where continuous knowledge of the output is essential, and where no trace of nitriding can be permitted, we now have equipment which will continuously check the over-all performance.

These new tools therefore make available to industry full means of determining accurately the presence of all gases continuously and simultaneously. They can be used by the equipment manufacturer to study the performance of generators and thereby improve the product. They should be used by production men to insure that the generators are operating at maximum efficiency and capacity. They will reduce to a minimum the mysteries and vagaries of heat treating operations and help to eliminate rejects from oxidation or decarburization.

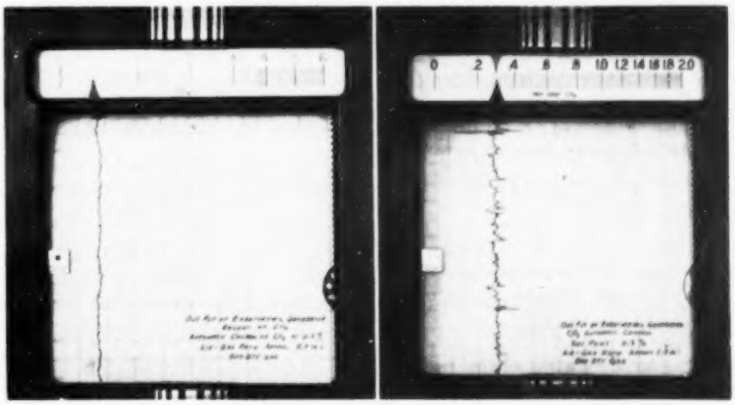


Fig. 5 – At Right Is Record of CO_2 Analyzer Governing Controller for Endothermic Generator. Set point is 0.3% CO_2. Air-gas ratio about 2.3. Thermal power of fuel gas, 800 Btu. Left is simultaneous record of CH_4 taken in the same prepared atmosphere

Round Table on Atmosphere Applications

The first of the panel discussions held by the Industrial Heating Equipment Assoc. at the A.S.M.'s annual convention and metal exposition considered the several types of industrial atmospheres now used by the metals industry. The papers to follow, p. 106 to 123, represent the second panel discussion of "Atmosphere Applications". While the subject is large enough for a sizable book, the abbreviated summary of principal points will undoubtedly serve as a refresher for the more expert metals engineers, and as a source of new ideas for those whose view is not so broad.

Elements of Gas Carburizing

*By WALTER HOLCROFT**

Modern gas carburizing requires a tight furnace, including proper entrance and exit locks, an adequate flow of atmosphere of correct composition, which can be approximately predicted, and time and temperature cycle proper for the desired surface carbon and hardenable depth.

Gas carburizing, as the name implies, is a process in which steel is heated above the critical point in an enveloping atmosphere of such nature as to add carbon to the surface. Once the surface carbon has been built up, diffusion takes place as a function of time to give the case depth required. During this time the surface carbon content must be continuously replenished.

While our present methods of gas carburizing cover a span of only 20 years, the basic idea can be traced back to at least the 1880's in the patent literature. Many types of equipment were sold in the United States from the early 1900's on. Continuous gas carburizing furnaces were in operaion in 1931.†

Three principal reasons account for our modern version of gas carburizing:

First, alloy foundries have been able to produce large, sound muffle sections which could be welded into a continuous tunnel through which the work could be moved.

Second, furnace engineers were able to take this material and design mechanisms to move steel parts through the tunnel so that each receives substantially the same treatment as to time at heat and type of atmosphere.

Third, physical metallurgists have acquired

*Executive Vice-President, Holcroft & Co., Detroit.
†See Editor's footnote opposite.

better knowledge of equilibria values of various carbonaceous gases.

As is well known, only a small percentage of the gas carburizing today is done in muffle furnaces. Most of it is either electrically heated or gas fired in radiant tubes. The two basic requirements in a gas carburizing furnace are as follows:

First we need a gas-tight hot chamber (generally of welded structural steel radiantly heated). Entrance and exit vestibules are generally used with double doors so the air may be purged from the vestibule before stock enters or leaves the furnace proper. Entering and discharge tunnels may be used with consequent increased requirement of prepared gas.

Second is the necessity for a prepared gas to envelop the work in the furnace in sufficient volume to create a slight furnace pressure and also to purge the vestibules. This amount will usually be adequate for the carburizing action with addition of hydrocarbon.

It is probably in the use of prepared gas and in the understanding of its function that the greatest advance in gas carburizing has been made. This matter has already been touched upon by the authors of papers in the first group – notably by Mr. Hotchkiss at the very beginning (p. 83) – who have shown the concept of equilibrium in a reversible reaction; that is to say, the extent to which the reaction progresses depends upon temperature and pressure.

A simple explanation might be given as a strong bottle containing carbon monoxide, carbon dioxide and carbon. We would heat this bottle and find, as the temperature increased, that the amount of carbon monoxide would increase and the amount of carbon dioxide and carbon would decrease. As the temperature was lowered the reverse would be true. If this heating were done step by step and a considerable time allowed at every temperature step, definite percentages of each constituent could be expected.

Equilibrium values have been accurately determined by the physical chemists so we are able to predict whether a given enveloping gas will tend to add or remove carbon from a hot steel. It should always be remembered that it is the analysis of the gas in the furnace that is important in determining carburizing potential.

Computing a Gas Analysis

In the gases with which we work in carburizing, two principal reactions need to be considered. First is:

2 parts $CO \leftrightarrows$ 1 part CO_2 plus 1 part carbon

the equilibrium constant, $K_1 = (CO)^2 \div (CO_2)$, varying with temperature, where $(CO)^2$ is the partial pressure (proportionate amount of CO in the gas mixture) squared, and (CO_2) is the proportionate amount of CO_2 for equilibrium.

The second reaction is:

carbon plus $H_2O \leftrightarrows CO$ plus H_2

the equilibrium constant, $K_2 = (CO) \times (H_2) \div (H_2O)$, varying with temperature.

The equilibrium constants for these two reactions increase as the temperature increases. For example, approximate values of K_1, based on carbon content of saturated austenite*, are:

1300° F.	1	1600	20
1400	3	1650	32
1450	5	1700	46
1500	8	1750	68
1550	13	1800	98

As an example let us figure the percentage of CO_2 allowable in a $CO:CO_2$ mixture when treating a 0.60% carbon steel at 1650° F. From the table above we find K_1 for saturated austenite at 1650° is 32. From the familiar iron-carbon

EDITOR'S NOTE – The historical development of accurate knowledge about cementation or case hardening is described at considerable length in Giolitti's "Cementation of Iron and Steel", whose American translation was published in 1915. It appears that Réaumur presented to the Academy of Sciences of Paris in 1720 the results of his patient investigations of case hardening of wrought iron by heating it in solid "cements" – a process then used in France and which he rightly assumed to be the first stage of the conversion of bar iron into blister steel as practiced in Germany since 1600 or earlier. He showed that the process involved the gradual diffusion of something inward from the surface. This something was proved to be carbon by the Swedish chemists Bergman and Scheele about 1775. For a century or so it was usually assumed that this carbon entered the steel through points of contact, solid to solid, although it was amply proven by many (notably Caron in 1861) that gaseous compounds, supposedly cyanogen, CN, expedited the action enomously. Giolitti himself may be regarded as the father of modern carburizing practice since he proved by rigorous experiments in 1905 to 1907 that *intimate* contact of gaseous carbon compounds with a hot iron surface is a prerequisite to case hardening at measurable speeds. This is commercially possible when the carbon carrier deposits carbon atom by atom on the hot iron surface, there to diffuse inward toward regions of lower carbon concentration.

*For lower surface carbon in steel the equilibrium constant is lowered in a straight-line relation.

equilibrium diagram (*Metal Progress* Data Sheet No. 38), austenite is saturated in plain carbon steel at 1650° F. at 1.2% carbon. Because the 0.60% carbon steel is exactly half the saturated austenite value of 1.2%, the K_1 value we use is half of 32 or 16.

Suppose now by gas analysis or CO indicator we find that the enveloping gas contains 20% CO; we can then find the allowable CO_2 for equilibrium with the 0.60% carbon steel surface (neither carburizing nor decarburizing) by substituting known values:

$$K_1 = \frac{(CO)^2}{CO_2} = 16 = \frac{(0.20)^2}{CO_2}$$

$$\text{whence } 16 \times CO_2 = 0.04$$

$$CO_2 = 0.0025 \text{ or } 0.25\%.$$

While such a gas (20% CO, 0.25% CO_2, balance an inert gas like nitrogen) will be neutral to 0.60% C steel at 1650° F., it would carburize at lower temperatures and decarburize at higher.

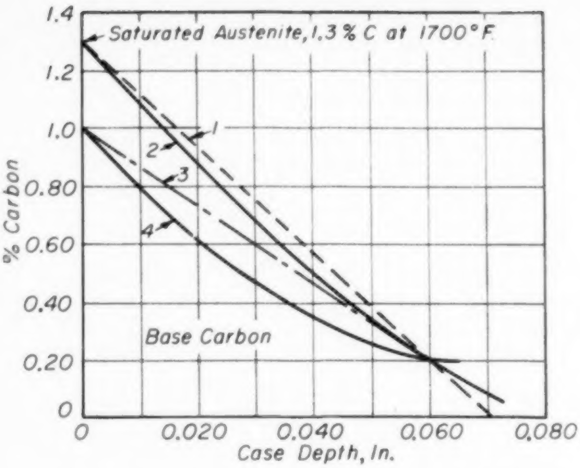
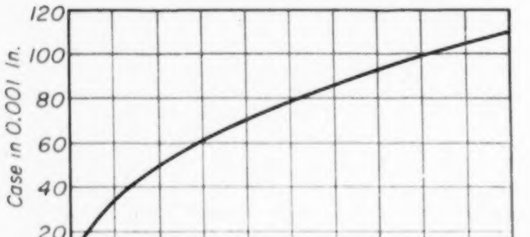


Fig. 2 – Theoretical Versus Actual Carbon-Depth Curves. 1 – Theoretical straight line from saturated austenite at 1700° to base carbon (0.20% C) at 0.060 in. 2 – Actual carbon-depth line for 0.060 in. at 1700° F. 3 – Theoretical straight line for 1.0% surface carbon. 4 – Actual carbon-depth line with controlled surface carbon

It is well known to the heat treating fraternity that the second reaction given above involving water vapor has an important effect on carburization and Messrs. Koebel and Cullen will discuss the application of dew-point measurement and control, pp. 110 and 114.

The most commonly used carburizing temperature is 1700° F. (Lower temperatures may be used for very light case depths or for specific core properties.) At 1700 the carburizing "potential" of carbon monoxide is very slight – that is to say, the very small amount of carbon that will be available from the decomposition of carbon monoxide is all that can be counted on as "useful" carbon before the carbon dioxide which is simultaneously formed slows down the reaction by bringing the gas mixture into equilibrium. For that reason a hydrocarbon gas is added; this accounts for almost all the carburizing action.

Fig. 1 – Relationship Between Time at Heat and Total Case Depth at 1700° F. By "total case depth" is meant distance to core carbon – uncarburized steel



The hydrocarbon may be either natural gas or propane. If natural gas, it will normally analyze 85 to 90% methane with the balance ethane and unsaturated hydrocarbons. All of these tend to break down at carburizing temperatures in the following order: *(a)* unsaturated hydrocarbons, *(b)* propane, *(c)* ethane, *(d)* methane. All deposit carbon and liberate hydrogen, the faster with increasing temperatures – and, of course, all reactions have equilibrium constants dependent on the hydrogen in the furnace atmosphere.

The necessary amount of hydrocarbon varies in production essentially as follows:

1. As the amount of surface area to be carburized increases, the hydrocarbon addition must be increased to supply more carbon.

2. As the required surface carbon concentration decreases from saturated austenite, the amount of hydrocarbon must be decreased.

Carburizing Rates and Case Depths

It is a familiar fact that the rate of carburizing varies as the square root of the time. As shown in Fig. 1, we may expect a total case depth of 0.025 in. in 1 hr. at 1700° F., but to get 0.050 in. requires 4 hr. To double the depth, you square the time (other conditions being equal). On the other hand, to get 0.005 in. would require only

2 to 3 min. This same square-root function means that the steel requires much more carbon in the early part of the process and that the hydrocarbon requirements decrease with time.

If we had perfect conditions the percentage carbon versus case depth would plot a straight line, and after about 6 hr. at 1700° F. would run from saturated austenite at the surface to core carbon at 0.060 in. as shown by Curve No. 1 of Fig. 2.* Actually, as shown by Curve No. 2, we get a line which drops below the theoretical except at the ends, a result caused by an insufficient carburizing potential in the early part of the cycle – a matter which is of less significance as the depth of diffusion increases. There is practically nothing we can do about this, and as we continue to aim for less-than-saturated austenite at the surface, the above tendency is accentuated, as can be seen by a comparison of Curves No. 3 (theoretical) and No. 4 (actual).

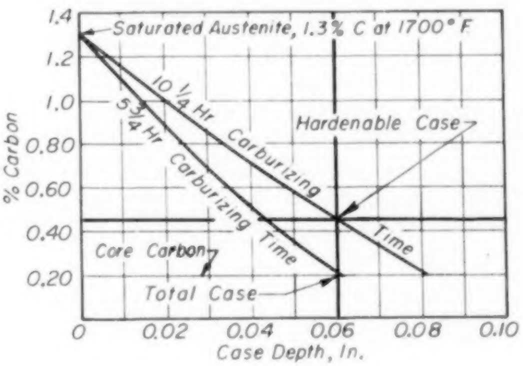
The reason all this is important is that we actually are interested in ***hardenable*** case depth, but must figure the time required at heat to carburize to core carbon at a considerably greater depth. Most metallurgists would read "hardenable case depth" to 0.40 to 0.50% carbon. Of course, if we used 0.40 to 0.50% carbon steel the hardenable case depth and the total case depth would be the same, but as we ordinarily carburize low-carbon steel, it is necessary to make proper allowances in time.

This point is very important and is illustrated in Fig. 3. Curve 1 shows a carbon penetration curve which has 0.060 in. of hardenable case – that is, metal with more than 0.45% C. It would require a 10.25-hr. cycle at 1700° F. Curve 2, on the other hand, shows a carbon penetration curve for the same steel and furnace conditions where the total case (depth to core carbon) is the same 0.060 in. It required only 5.75 hr. at 1700° F. However, the hardenable case (depth to 0.45% C) for the second set of conditions is only 0.042 in.

It can be seen from these curves how greatly the method of "reading" case affects the capacity of any carburizing furnace. This particular point has caused more controversy between purchaser and furnace builder than any other single thing in gas carburizing.

This leads us rather naturally into the question of furnace capacity. We can't say that any particular furnace is good for X lb. per hr. of work without knowing the type of work, type of case, operating temperature, type of quench and case depth. All furnaces, whether continuous or batch, have so many square feet of effective hearth area. Our first problem in determining furnace capacity, then, becomes one of laying out the pieces to be gas carburized and determining how many pieces we can get in each square foot, bearing in mind the limitations of heating rate, gas circulation and quenching equipment. Having determined the maximum practicable number of pieces per square foot, we can then go back to time requirements from case-depth curves and determine the capacity.

Fig. 3 – Carbon-Depth Curves Showing That a "Total Case" of 0.060 in. May Be Acquired in 5.75 Hr., But a "Hardenable Case" (C above 0.45%) of 0.060 in. Requires 10.25 Hr. Same steel, temperature, atmosphere



W. H. Holcroft

Associated with Holcroft & Co., ever since graduation with a Bachelor of Science degree in Chemical Engineering in 1926, Mr. Holcroft has been vice-president and technical director for the past 16 years. Long active in ASM, he is also a member of A.S.T.M., A.F.S., S.A.E. and Army Ordnance Association.

*Editor's Note – These conditions were discussed by Floyd E. Harris in a notable series of articles in *Metal Progress* starting in March 1944 and ending in April 1945. See also his data sheets, No. 82 and 83 in the *Metal Progress* set.

Equilibrium Relationships for Dew Point Control

*By NORBERT K. KOEBEL**

While equilibrium relationships between constituents of prepared atmospheres are valuable for theoretical, research and developmental studies, heat treating operations in thoroughly reacted endothermic gas are much more adequately controlled by keeping the dew point in the furnace steadily at a correct value.

THE MOST valuable information for the heat treater operating controlled atmosphere processes is accurate, reliable data to show him how to adjust his furnace atmosphere to obtain specific results, such as carburizing or carbon restoration to a certain carbon content, or the hardening of constructional steel or toolsteels without surface change. The most frustrating and discouraging job a heat treater or metallurgist can tackle is the application of theoretical equilibrium curves to a specific problem where quantitative and precision carbon control is demanded.

It would be well, therefore, to inquire into the causes of this state of affairs and what can be done about it.

Mr. Hotchkiss in the very first paper in this series (p. 81) outlines very briefly the theoretical considerations, and others allude to equilibrium constants as determined in laboratory studies. A more-or-less complete list of these chemical reactions that occur between the components of a furnace atmosphere and the carbon, iron or oxide in or on the steel is:

$$Fe + H_2O \rightleftharpoons FeO + H_2 \quad (1)$$

$$Fe + CO_2 \rightleftharpoons FeO + CO \quad (2)$$

$$CO + H_2O \rightleftharpoons CO_2 + H_2 \quad (3)$$

$$2CO \rightleftharpoons C + CO_2 \quad (4)$$

$$CH_4 \rightleftharpoons C + 2H_2 \quad (5)$$

$$Fe_3C + CO_2 \rightleftharpoons 2CO + 3Fe \quad (6)$$

$$3Fe + CH_4 \rightleftharpoons 2H_2 + Fe_3C \quad (7)$$

$$Fe_3C + H_2O \rightleftharpoons CO + H_2 + 3Fe \quad (8)$$

Faced with this large group, we might simplify matters somewhat by saying that reactions (1) and (2) determine whether the hot steel will scale. If the composition of the gas is correct for bright hardening or carburizing, the $H_2O:H_2$ and $CO_2:CO$ ratios will always be low enough to obtain bright steel parts after relatively fast cooling or a quench.

Reactions (3), (4) and (5) concern changes in the gaseous constituents of the atmosphere as the temperature varies, but since (4) and (5) also involve deposition or absorption of carbon, they are also of great importance to correct heat treatment. However, reactions (6), (7) and (8) are the ones usually drawing the most attention in any discussion of carburizing.

Theoretical Equilibrium Curves

The best treatment of the theory known to the present writer is the article by J. B. Austin and M. J. Day, "Chemical Equilibrium as a Guide in the Control of Furnace Atmospheres" in the controlled atmospheres symposium held by the ⊕ in 1942. Their equilibrium curves and physico-chemical calculations show the trend of the reaction and give fundamental information on which to base our choice. The word "fundamental" should be underlined, because there seem to be too many people who are bemused by these calculations when facing a shop problem.

For example, suppose we had a gas which we knew contained 20% CO and 0.10% CO_2. We could figure K for Fig. 1† by changing the percentages to mol fractions, dividing by 100 and substituting in the equation

$$K = \frac{P^2 \text{ for } CO}{P \text{ for } CO_2} = \frac{(0.20)^2}{0.001} = \frac{0.040}{0.001} = 40$$

*Director of Research, Lindberg Engineering Co., Chicago.

†From Austin and Day, a more accurate presentation than the adoption of Becker's 1930 work shown in the upper left hand diagram on p. 85 in Mr. Hotchkiss's paper.

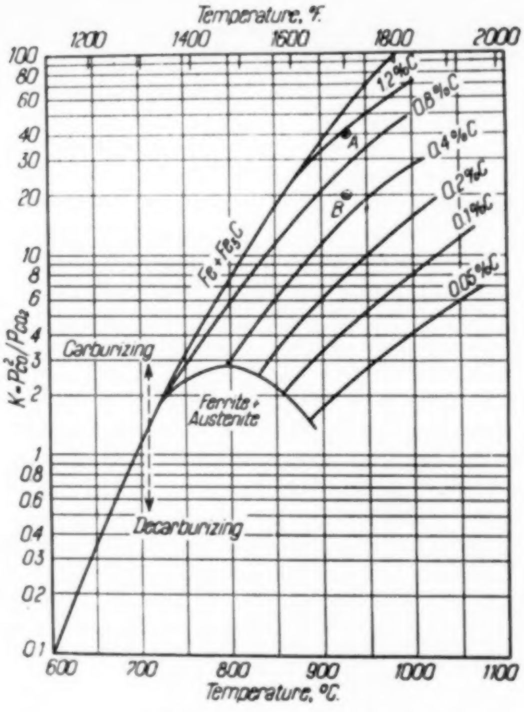


Fig. 1 – Relations Between $CO:CO_2$ Content in Gas Atmosphere, Temperature and Carbon Content in Steel for Equilibrium in the Reaction:
$$Fe_3C + CO_2 \rightleftarrows 3Fe + 2CO$$
According to Austin and Day's work in 1942

Now, if this gas is in a furnace at 1700° F. it should be neutral (neither carburize nor decarburize) to a steel with about 1.15% C, as shown by point A. However, note what would happen if an error of 0.10% CO_2 was reported in the analysis; it actually was 0.20%. K then becomes 20 and point B on Fig. 1 shows the atmosphere really is neutral to a steel with about 0.60% C.

An ordinary Orsat apparatus could not be used to give the metallurgist the required accuracy in his gas analysis. Either slow, tedious gravimetric analysis or an infrared analyzer (costing $5000 or $6000) would be required if this method were used for carbon control. Even then, the results could not be depended upon, for, as Austin and Day say, "Unfortunately, existing data are far from satisfactory since they fail to agree among themselves; even worse, they fail to meet certain thermodynamic requirements."

Discussing Austin and Day's paper, the present writer compared some results from practical heat treating with the theoretical curves. Very accurate gas analyses were made from a furnace atmosphere containing 0.6% CO_2, 0.0% O_2, 33.3% CO, 1.9% H_2, 0.0% CH_4, 0.15% H_2O, and balance N_2. Actual results could not be fitted into the theoretical curves. Furthermore, they showed that the alloy content of the steel not only had an influence on the rate of reaction, but also on the direction in which the reaction went. I therefore concluded that the theoretical equilibrium curves had little practical value in predicting the action of controlled atmospheres on the commonly used tool and alloy steels. (In this check, it will be noted that the hydrogen was very low and the methane was zero, thus eliminating possibilities of errors due to a complex system.)

As long as 19 years ago, I found that a dry mixture of 34% CO and 66% N_2 was not strongly carburizing as predicted from equilibrium curves. In fact, the mixture very slightly decarburized high-carbon steels and only slightly carburized low-carbon steels. A hydrocarbon must be present to supply the nascent carbon for carburizing – a matter now universally recognized.

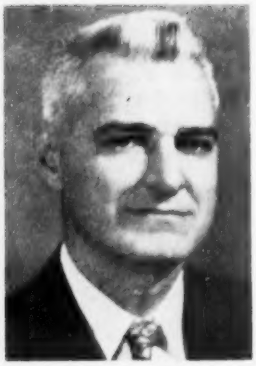
In summarizing the situation and without decrying in the least the value of equilibrium data to scientific studies, they are of very doubtful utility to the shopman and practicing metallurgist because:

1. Their accuracy is still doubtful for plain carbon steels and unquestionably unsuitable for alloy steels.
2. True equilibrium cannot exist within the gas flowing through a heat treating furnace – except perhaps in tightly sealed retorts or bell covers.
3. Gas analyses of sufficient accuracy cannot be rapidly made.
4. Their use is indirect, involved, and beyond the comprehension of most shopmen.

Control by Dew-Point Measurement

Faced with these circumstances, the working metallurgist must use other means to control furnace operations, so Lindberg Engineering Co.'s research laboratory conducted a quite extensive investigation which was reported in *Metal Progress* for February 1954. If the reader is intrigued by the following brief summary of our findings, he should consult the original publication. In our experiments, weighed and measured disks of steel where heated in a toolroom furnace in known atmosphere and temperature. If there was no change in weight nor change in surface carbon as examined under the microscope, then it was judged that the particular steel was in practical equilibrium with that particular atmosphere at that particular temperature.

Results were correlated with dew-point read-



Norbert K. Koebel

Ohio State and Battelle graduate (M.S. in Metallurgical Engineering), Norbert Koebel spent four years as metallurgist at Eastman Kodak Co.'s camera works. Since 1940 he has been director of research for Lindberg Engineering Co., where much of his attention has been given to heat treatment in controlled atmospheres.

ings not only to achieve the objective stated above, but because relatively inexpensive indicating instruments are available for so measuring small amounts of water vapor accurately. Such an instrument is portable, can be used by any shopman, and the measurement can be made in a few minutes.

Further, the use of only one constituent, moisture, is justified because a definite, reproducible stoichiometric relationship exists between the constituents (including H_2O) of a completely reacted endothermic gas at all gas-air ratios. For example, for the dew points under 40° F. normally used on 0.60% to 1.50% C steels, the CO_2 is 0.0% (by Orsat measuring devices) and the CH_4 runs nearly constant under 0.5%. Since the CO_2 and CH_4 are extremely low, the carbon potential can then be varied by changing only the H_2O. For more humid gas the CO_2 may reach 0.5% for the high dew points and the CH_4 will approach 0%. The CO and H_2 will likewise shift slightly, but this does not affect the accuracy of our laboratory results because the direct measurement of the carbon potential at the various dew-point measurements by the gain-in-weight method takes the gas composition into consideration. "Equilibrium" curves and conditions for various steels, as determined in our work, are assembled on the opposite page.

In using these data, it is of utmost importance to take the dew point of the gas in the furnace chamber and not from the generator exit. The dew point will vary in the furnace, depending upon the temperature, due to the water-gas reaction, (3) above, and also due to air infiltration. Still more important, the dew point from the furnace will immediately show a restricted flow of atmosphere, leaky furnace seals, or infiltration of moisture or air from the quench tank.* Any air leaking into the furnace or carried into the furnace with the charge will raise the dew point. Likewise, opening and closing a door will increase moisture even though the door is protected by a flame curtain. Sufficient atmosphere must flow through the furnace to return the dew point to the desired level before the work reaches temperature.

Application of the curves on p. 113 for neutral hardening is quite obvious. All that is required is to adjust the endothermic generator and flow of atmosphere through the furnace so the dew-point temperature as read from the chart is maintained in the furnace chamber at the temperature at which the steel is to be hardend. A spread of $\pm 5°$ F. in the dew point will usually give perfect results, as determined by the hardness tester. A general rule to follow is that the higher the temperature or the longer the soaking cycle, the closer the dew point should be controlled to that shown on the curves.

The equilibrium curves are particularly useful in carbor correction. Aircraft specifications on bolts, for example, require that any millbark on the surface be corrected to the carbon content of the core. Decarburization is not removed in manufacturing bolts with rolled threads, and a low-carbon surface on the thread lowers the fatigue properties. All that is required is to soak the bolts long enough at the hardening temperature with the dew point adjusted in the furnace as shown on the curve for the steel being treated.

(*Continuation on p.* 114, *beyond the insert*)

*In the discussion at the Industrial Heating Equipment Assoc.'s panel, R. H. Akers, metallurgical engineer, Chandler Products Corp., said that he had observed in production equipment that the dew point of the furnace atmosphere is very often lower than that originally generated. This increase in carbon potential is due to the hydrocarbons available from oily work charged and from the oil quench. He frequently charges oily work specifically for this added potential. The oil quench exhauster is an excellent means of dropping the dew point in a very short time.

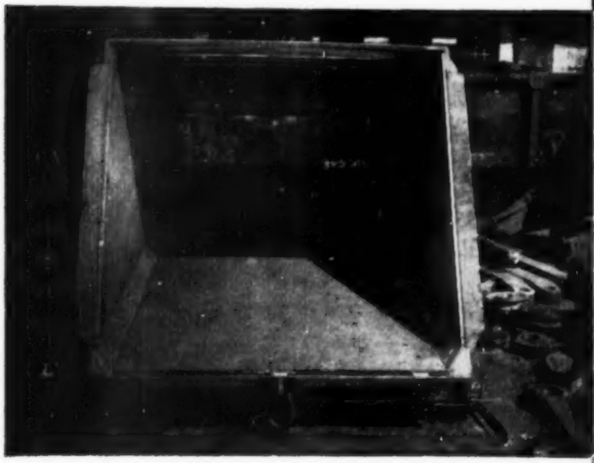
Proper carbon restoration is apparent to the metallographer only by the grain refinement due to the absorption of carbon.

Finally, he observed that unequal depths and degrees of decarburization are no problem provided the furnace atmosphere is in equilibrium with the carbon content of the steel.

USS "T-1", A Nickel Alloy Steel, Helps Save Money

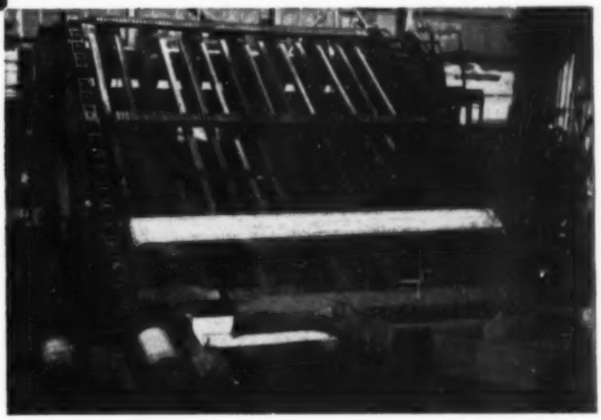
Lips of Nickel Alloy Steel show 11 times the life of the previous material used . . . in Clamshell Bucket

T-1 steel not only replaced a more expensive material here, but also outlasted it by 11 to 1. In this application, T-1 is still on the job after 11 months, handling open hearth sinter, whereas a wear resisting steel cracked and failed in 30 days under abrasion, impact and operating temperatures of 500 to 600°F.



4 to 1 Better Service than carbon-manganese steel . . . in Skip Car Bottoms, Sides and Bail Plates

On skip cars handling coke, ore and limestone, T-1 steel bottoms, sides and bail plates are saving money. So far they have outlasted carbon-manganese steel 4 to 1. This four-fold longer life means more use per dollar for T-1 steel even though its initial cost is about twice that of the steel it replaced.



Unmatched Performance under heat and wear . . . in Blooming Mill Conveyor Chain

Here's a 40″ blooming mill conveyor chain for lifting hot slabs at U. S. Steel's Ohio Works. Various materials used for chain failed under the severest impact conditions imaginable, caused by falling or jammed hot slabs. Notice the good appearance of the present chain made from T-1 steel. This product has far outlasted all previously used materials.

These applications in U. S. Steel's Ohio Works show how T-1 steel can reduce your maintenance, operating and repair expenses under like conditions. Write for complete details.

INCO
TRADE MARK

THE INTERNATIONAL NICKEL COMPANY, INC. 67 WALL STREET NEW YORK 5, N. Y.

Safe Handling of Atmosphere Furnaces

(From "Protective Atmospheres", by A. G. Hotchkiss and H. W. Webber, John Wiley & Sons, Inc., 1953)

Conditions vary with equipment design; consequently: **Follow the Makers' Instructions!**

The management should insure, by periodic check and adequate maintenance, that all safety equipment, interlocks, controls and valves are operating properly.

The prime essential is that all operating and maintenance men clearly understand the hazards and can act warily and promptly whenever normal operations are interrupted.

Principal points for the men to understand are:

1. The difference between inert and combustible gas.
2. Most prepared atmospheres contain more than 4% hydrogen or 12.5% carbon monoxide, the low limit for explosion in air.
3. That any air-gas mixture with more than 1% oxygen may ignite.
4. That the minimum ignition temperature of hydrogen or carbon monoxide is close to 1100°F.
5. Given a 300° safety margin, any furnace or part of it less than 1400°F. constitutes an explosion hazard.
6. On the other hand, any common gas mixture can be put into a 1400° or hotter furnace with safety.
7. To purge a furnace requires at least five times as much air or inert gas as the volume of the furnace itself.
8. Before any repairs are made within a furnace, *disconnect* the gas lines, freshly purge the furnace, and blow air through the furnace continuously.
9. That carbon monoxide is extremely toxic, and therefore unburned furnace or generated gases should not be exhausted into a room.
10. If power or gas fails, shut down the furnace promptly. If valuable work in process must be protected, switch to reserve tank of protective gas, light gas curtains at all doors.

Rules for Starting and Stopping Furnaces Containing Combustible Gas*

By far the best way is to purge air out of the furnace on starting up, or to purge combustible atmosphere out of the furnace on shutting down with at least five volumes of inert gas (nitrogen or carbon dioxide) from an outside storage tank. This is especially desirable for low-temperature furnaces (operating below 1400° F.). If inert gas is unavailable, proceed *as instructed by the furnace builder;* in general, as outlined below:

Bell-Type Furnace

To Start Up

Place load on base

Light pilots

Start flow of gas and make sure that gas is burning freely at all inlets

Lower retort over load into its sand or liquid seal

Purge air out of retort with five volumes of gas

Reduce gas flow to normal; continue for 20 min. before starting circulating fans

To Purge (when retort is at 300°F. or cooler)

Stop circulating fans

Raise retort *slowly* 2 ft. above base

Ignite gas under retort immediately with long handled torch

Turn off atmosphere gas

Low-Temperature Furnace
(Cooler Than 1400°F.)

Purge chamber with five volumes inert gas, before starting up or shutting down. Otherwise:

To Start Up

Bring furnace to temperature. Open doors

Place portable pilot light (torch) at gas entrances inside the chamber

Start flow of atmosphere gas

When gas ignites, remove pilots

Close doors almost completely

Light permanent flame curtains at entrance and exit

When gas coming from furnace ignites, furnace is ready for operation

To Shut Down

Keep furnace at heat; maintain flame curtains

Slowly open entrance and exit doors wide

Shut off atmosphere gas

When furnace is clear of flame, it is purged

Horizontal Batch and Continuous Furnace
(No Cooling Chamber)

To Start Up

Heat furnace uniformly to 1400°F.

Open entrance and exit doors slightly

Light pilots at gas entrances inside the chamber

Start flow of gas.

When flame appears at both doors, heat treating operations can start.

To Shut Down

Do not allow any part of furnace to cool below 1400°F.

Open all doors

Turn off atmosphere gas

When furnace is clear of flame, it is purged

Horizontal Batch and Continuous Furnace
(With Cooling Chamber)

To Start Up

Close all doors

Bring furnace to heat (hot chamber above 1400°F.)

Close entrance, open doors fully between heating and cooling chambers, open exit slightly

Light pilots or flame curtains at all doors

Start flow of atmosphere gas *into hot chambers only*

When gas burns at exit, furnace is ready.

To Shut Down

Keep furnace at heat (above 1400°F.)

Open doors between heating and cooling chambers

Make sure that flame curtains at entrance and exit doors burn 3 in. high above sills

Open wide the entrance and exit doors

Close all cocks on atmosphere gas entries

When furnace is completely free of flame, it is purged

* For full details consult "Loss Prevention Bulletin 1470" by Factory Mutual Engineering Division, 184 High St., Boston 10.

Life of These Punches Went Up

350%

with

Ludlum DBL-3
High Speed Steel

Application of Special Heat Treatment Did the Trick:

These DBL-3 punches (2⅞" dia. by 10½" long) are used to draw and flatten hot or cold rolled stock .140" thick. With conventional heat treatment, their performance was 25% better than Material B and 50% better than Material C. But A-L Metallurgical Service recommended the *additional* heat treatment listed below, improving the performance of DBL-3 to 150% over B *and 350% over Grade C!*

1. Carburize at 1950°F
2. Oil Quench
3. Draw at 1025°F
4. Draw at 1025°F again
5. Finish grind
6. Draw at 750°F to relieve grinding stress
7. Nitride 72 hours at 950°F (case depth of approx. .015)

Ludlum DBL-3 holds a fine grain over a wide hardening range. With its higher carbon and vanadium content, it also has better abrasion resistance than other standard high speed tool steels. Our Metallurgical Service is ready to help improve *your* production operations, too. Just call our nearest branch office, or write *Allegheny Ludlum Steel Corporation, Oliver Bldg., Pittsburgh 22, Pa.*

Write for your copy of "CUTTING TOOL MATERIALS"

This 36-page booklet analyzes and compares all A-L grades: carbon, high speed, cast alloy and carbides. Includes data on handling and treatment . . . invaluable for production men.

ADDRESS DEPT. MP-59

For complete **MODERN** Tooling, call

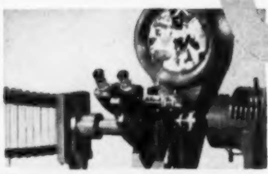
Allegheny Ludlum

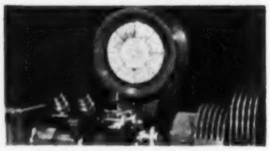
WAD 8186

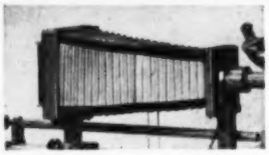
A-L FINE TOOL STEELS SINCE 1854

How Bausch & Lomb Balphot Metallograph

MAKES YOUR WORK EASIER

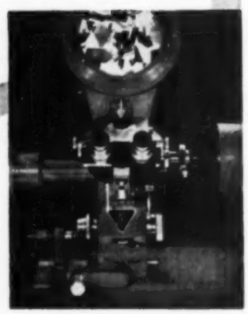






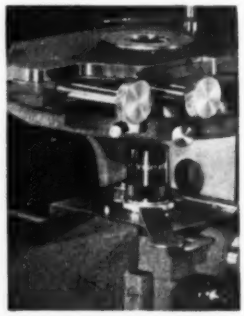
Shows detailed EASY-TO-SEE images... 3 ways!

Instantly, at the flick of a switch, the B&L Balphot Metallograph is ready for (1) Direct visual study, with interchangeable binocular and monocular microscope bodies; (2) Group viewing, grain size determinations and dirt counts with the exclusive *Magna-Viewer* projector screen; or (3) Photomicrography, with 5x7 camera (magnifications from 25× to 2000×). Complete facilities for comprehensive examination ... at your fingertips!



SAVES EFFORT

You sit relaxed, with all vital controls directly before you—focusing, objective change, stage revolution, mechanical stage adjustments, and illumination selection controls, *all within effortless reach.* Just move your head and your vision shifts from the microscope to the *Magna-Viewer* projector screen. You're comfortable, fatigue-free, for your best work.



SAVES TIME

No coarse focusing! No tedious refocusing when changing objectives! Cam-activated stage elevator instantly, accurately places desired objective in proper parfocal position. Your work proceeds without interruption or delay.

See for yourself, in an actual demonstration, how the B&L Balphot Metallograph *makes your work easier!*

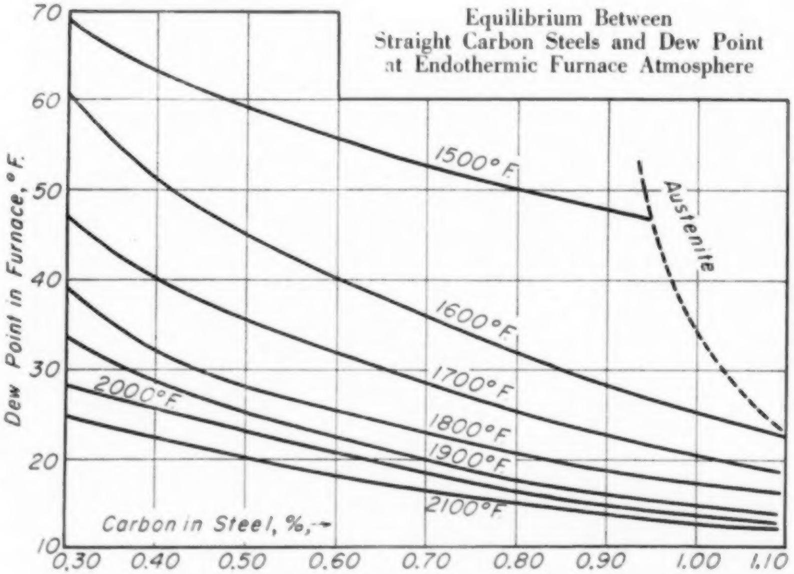
WRITE for demonstration (no obligation, of course) and Catalog E-232. Bausch & Lomb Optical Co., 63835 St. Paul Street, Rochester 2, New York.

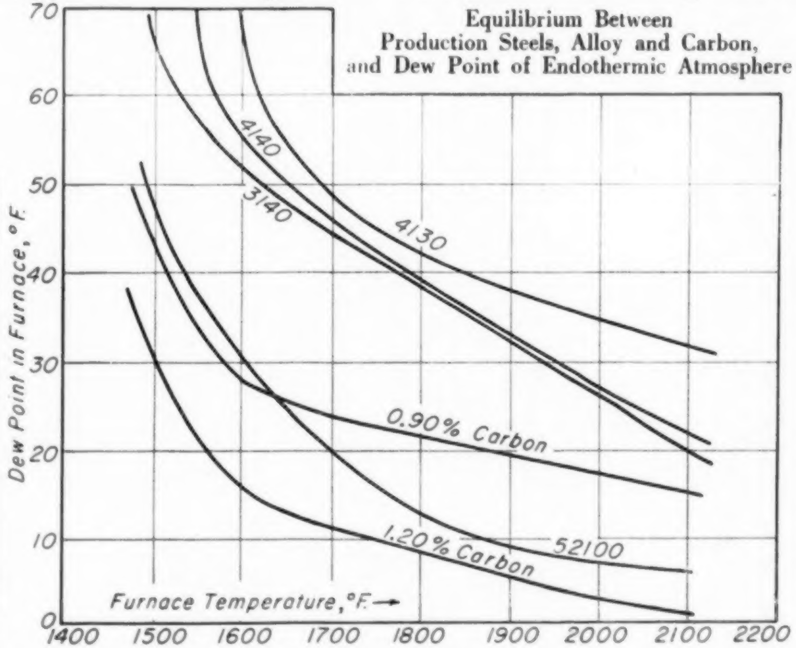
BAUSCH & LOMB

SINCE B&L 1853

Metallurgical Equipment

Equilibrium Between Steels and Dew Points of a Prepared Furnace Atmosphere





Dew Point Temperature in Furnace Using "Hyen" Endothermic Atmosphere for Hardening Some Common Types of Toolsteels

Type	Nature	Typical Steel	Furnace*	Minimum	Equilibrium†	Maximum	Type
IV-B	Cr-W-Mo hot work die steel	Vanadium-Alloys' Hotform	1850° F.	40° F.	46.5° F.	54° F.	IV-B
IV-A-2	5 Cr, 1Mo, 1C, air hardening	Braeburn's Airque	1750	40	45	50	IV-A-2
III-B	Si-Mn shock resisting chisel steel	Carpenter's Solar	1550	40	52.5	60	III-B
II-A	Mn nondeforming, oil hardening die steel	Latrobe's Badger	1450	45	50	55	II-A
II-C	High-carbon, high-chromium, oil hardening	Allegheny Ludlum's Huron	1750	20	—	70	II-C
III-D	Low-tungsten, chromium chisel steel	Allegheny Ludlum's Seminole	1750	40	42	45	III-D
II-D	High-carbon, high-chromium, air hardening	Vanadium-Alloys' Ohio Die	1850	20	—	70	II-D
VI-K	Tungsten fast finishing steel	Carpenter's KW	1550	23	27	33.5	VI-K
I-C	C-V shallow hardening die steel	Crucible's Alva	1500	45	50	55	I-C
II-A-3	High-carbon, low-tungsten, oil hardening	Allegheny Ludlum's Utica	1550	25	31.5	36	II-A-3
VI-F	Cr-Ni-Mo toolsteel	Carpenter's R.D.S.	1500	50	60	65	VI-F
V-C-1	18-4-1 high speed	Crucible's Rex AA	2350	0	8.5	10	V-C-1
V-A-2	5-5-5 W-Cr-Mo high speed	Bethlehem's HM	2250	5	12	15	V-A-2

*Appropriate mid-range of hardening temperature for the type. †Temperature for equilibrium dew point.

For example, if an S.A.E. 4140 steel were being heat treated and simultaneously carbon corrected, a hardening temperature of 1600° F. would be used, and the upper left figure on p. 113 shows that an endothermic atmosphere with dew point in the furnace of 55° F. would be in equilibrium with this steel. If the bolts were soaked long enough at 1600° F., the carbon would be restored to 0.40% and there would be no danger of ever exceeding this amount.

Rules for Using Dew-Point Curves

In using the data on p. 113, the following rules must be kept in mind:

First, they apply only to a completely reacted endothermic gas with analysis approximately 0.0 to 0.5% CO_2, 0.0% O_2, 1.0% max. CH_4, 20% CO, 40% H_2, and balance N_2. (When cracking propane instead of natural gas, the CO will be higher and the H_2 lower, but this will not result in any great discrepancy if the gas is completely reacted, as the CO_2 is practically zero and the methane does not exceed 1.0% max. The same applies when using mixed or city gas, which results in a lower CO and higher H_2.)

Second, the dew point must be taken from the work chamber by means of an Inconel or high-alloy sampling tube.

Third, an accurate and reliable dew-point meter must be used. (The old method of checking dew point by the appearance of fog on a cold mirror is not reliable. In the low range, the operator can be 10 to 20° off, due to supercooling. An "Alnor Indicating Dewpointer" is recommended for dew-point measurements and especially to be used to check continuous recorders. This equipment withdraws samples from the furnace at frequent intervals, compresses the gas, expands it suddenly in front of an observation window. If consecutive samples compressed to P_1 and P_2 respectively show fog and no fog, the dew point is bracketed between two tabular values.*

Fourth, the curves will not apply if the endothermic generator gas is enriched with a hydrocarbon gas or ammonia.

*George E. Wiegert, metallurgist for Goodman Mfg. Co., Chicago, commented that he had checked some of the curves on p. 113 for carbon steels (within 0.02% carbon) in several furnaces, using endothermic generators by placing a circuit of fine wire into the furnace. Tests ranged from 0.30 to 0.80% carbon in plain and low-alloy steel and temperatures from 1500 to 1700° F. Carbon content of the hot wire was measured by its electrical resistance (calibration having previously been made by combustion analysis).

Dew Point Control in Practice

*By O. E. CULLEN**

Since analysis of moisture in furnace gas is so much quicker and more accurate than CO_2 analysis, and improved (even automatic) equipment is available, the trend is toward furnace control by dew point when carburized or heat treated work is specified closely as to surface carbon or carbon penetration.

IT HAS BEEN well established that the dew point of an endothermic atmosphere is a theoretical and practical measure of its carbon potential. Inasmuch as any use of calculated equilibrium data must express water vapor as partial pressures or as percentages by volume, some graphic relationship between dew point and water vapor content should be given. Also, since CO_2 is also a measure of carbon potential, it might be well to demonstrate the relationship between CO_2 and H_2O in the ordinary endothermic atmosphere (about 20% CO, 40% H_2, 40% N_2 and small amounts of CH_4, H_2O, and CO_2).

Dew point is the temperature at which mois-

*Chief Metallurgist, Surface Combustion Corp., Toledo, Ohio.

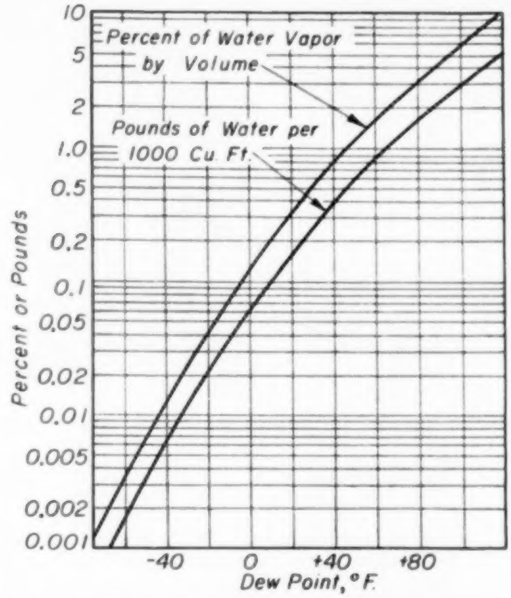


Fig. 1 – Relationship Between Dew Point in °F. and % H_2O by Volume, and Weight H_2O per 1000 Cu.Ft.

ture will begin to condense out of an atmosphere. (In scientific terms it is the saturation temperature corresponding to the partial pressure of water vapor.) By either definition, the dew point versus percent water can be charted as in Fig. 1.

There is ample evidence that the percent by volume of either CO_2 or H_2O is representative of the carbon potential in endothermic types of furnace atmospheres. Under most operating conditions, the heat treating temperatures and carbon requirements are such that carbon potential must be controlled within such narrow ranges that the amount of either CO_2 or H_2O must be determined very accurately. Figure 2 shows the relationships for steel at 1700° F. For equilibrium with a carbon content of 0.50%, an Orsat reading of 0.20% CO_2 and a dew point of +29° F. are required. Again, for equilibrium with 0.60% carbon, the carbon dioxide reading must be 0.16% and the dew-point reading +24° F. The difference in carbon dioxide readings for this change of ten points in the carbon is 0.04% on the Orsat (beyond its limit of accuracy), but 5° F. on the thermometer.

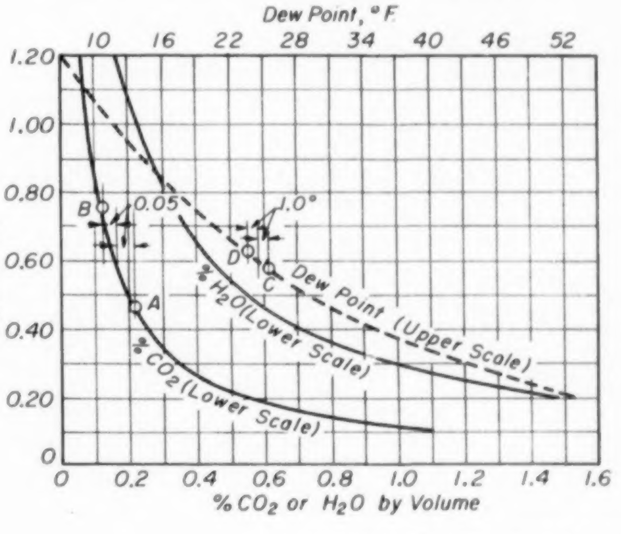
Now assume reasonable limits of ±0.05% CO_2 on the Orsat and ±1° on the dew-point thermometer, when treating 0.60% carbon steel at 1700° F. If the Orsat reading is on the low side, the atmosphere would actually produce surface carbon of 0.47% C (Point A on Fig. 2), but if on the high side it would be at 0.74% (Point B). By dew-point determination, on the other hand, the limits of control are 0.57 to 0.63% carbon (Points C and D in Fig. 2). It therefore appears that the growing interest in dew point as a carbon potential indicator or controller is reasonable and most logical.

Application of Dew-Point Equilibria

The theories behind control of carbon potential by dew-point readings are not of recent origin but their application to heat treating atmospheres is comparatively new. As in any art being evolved, misconceptions arise; also, departure from theoretical values may be knowing or unknowing, for reasons of expediency.

At Surface Combustion Corp.'s laboratories we have calculated curves for 1500, 1600, and 1700°, as shown in Fig. 3, from the best available data on equilibrium reactions involving the component gases in an endothermic atmosphere. A large number of actual test results, as indicated, confirmed the accuracy of these three curves; some of these test results came from a laboratory test

Fig. 2 – Relation Between Carbon Potential of Endothermic Gas (20% CO, 40% H_2, 40% N_2) at 1700° F. and H_2O or CO_2 content. Since graph for dew point is so much flatter than that for CO_2 at carbon contents of constructional steels, a small error in moisture determination does not lead to such large heat treating variations as a small error in CO_2 analysis.



furnace in which steel shim stock was heated in a prepared atmosphere in very close agreement with equilibrium values required. A large number of the tests were made in industrial heat treating furnaces where the rate of gas flow was controlled so as to approach equilibrium – not too difficult except in furnaces which are not fairly tight.

The curve for 1600° F. parallels Mr. Koebel's corresponding curve, p. 113, "Equilibrium Between Straight Carbon Steels and Dew Point" at only about 2° or 3° lower on the dew point scale. The true equilibrium curves for 1500° F. and 1700° F. of our Fig. 3 are nearly parallel to the companion 1600° F. curve and thus do not approach Mr. Koebel's curves except for low-carbon steel.*

It will be appreciated that the preparation of a true equilibrium atmosphere for introduction into a commercial furnace would be rather impractical. Therefore, it becomes necessary to generate a gas of an analysis reasonably close to equilibrium for its various components and then bring about a more complete reaction in the furnace chamber. How closely this can be done will of course depend upon furnace conditions. Any radical departure from true equilibrium will result in an unbalance which must of necessity depend upon the rate of flow of the atmosphere to control the carbon potential. Furthermore, operation under such unbalanced conditions will of necessity vary from furnace to furnace and plant to plant.

Orville E. Cullen

The chief metallurgist for Surface Combustion Corp. in Toledo graduated in metallurgical engineering from the University of Detroit in 1930. After six years with General Reduction Corp., wrestling with problems concerning direct reduction of sponge iron, he joined Surface Combustion's staff. He has been active in Society affairs–past chairman of the Toledo Group, educational chairman, and now a member of Ⓐ Metals Handbook Committee.

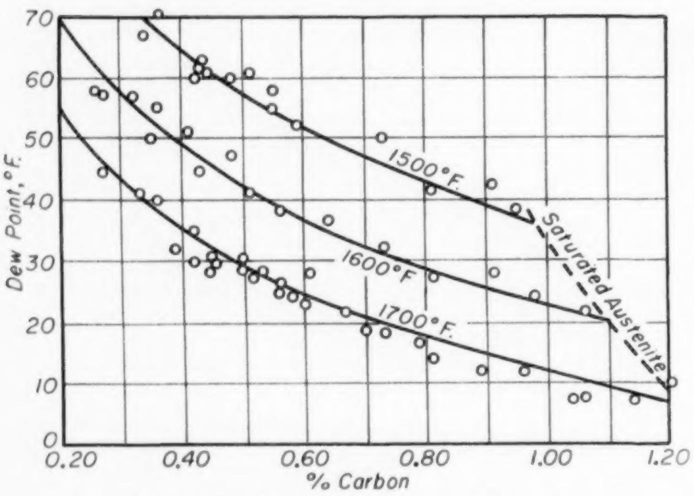


Fig. 3 – Calculated Curves for Equilibrium Between Carbon Content of Austenite and Dew Point of Endothermic Gas (20% CO, 40% H_2, 40% N_2). Circles represent test Results from laboratory or production furnaces

Dew-Point Apparatus

Various methods have been devised for measuring dew point and most of them have been used for furnace atmospheres or generator gas. Basically, the common methods fall into three classes:

*In the discussion at the meeting, the audience was reminded of Mr. Koebel's statement that a variation of 5° in the dew point seems to cause little trouble with the work unless it is soaked for a long time or at an unusually high temperature. If this statement be accepted, it would appear that a furnace could be satisfactorily operated if controlled by either Mr. Koebel's or Mr. Cullen's set of curves. However, W. P. Benter, Jr., and D. J. Girardi of Timken Roller Bearing Co.'s metallurgical department, said that more accurate control is desirable. "At the 0.60% carbon level a difference of 5° F. in dew point corresponds to a carbon change of about 0.10%, and need for accurate dew-point control is even more evident if this comparison is made at the 1.00% carbon level, where a 0.10% carbon change corresponds to a difference of about 3° F. in dew point. Even when it is desirable to carburize to a maximum allowable carbon level, too great a variation in surface carbon is undesirable for its influence on physical properties and also for its influence on case depth to the 0.40 or 0.50% carbon level."

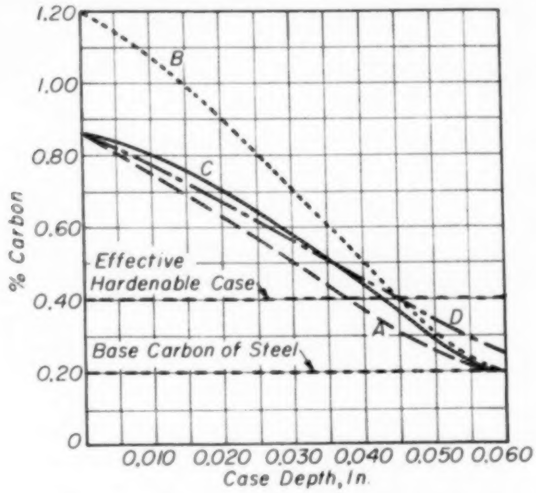


Fig. 4 – Carbon-Penetration Curves for Typical Gas Carburizing at 1700° F. A, B, and C are all for cycles of 5.5 hr. In A a low carbon potential (for 0.85% C) was maintained throughout and effective hardenable depth is 0.037 in. In B a high carbon potential (for 1.20% C) was maintained throughout, and in C this was maintained during the first part of the cycle and a diffusion period at 0.85% C potential followed. In both, the effective hardenable depth is about 0.045 in. If the low carbon potential was maintained throughout, it would take 7¼ hr. to produce that hardenable depth, as shown by curve D

Class I condenses a film of water or ice on a cooled metal surface. It can be portable or fixed, and operated manually or mechanically. Results may be visual, indicating, recording, or controlling. One special requirement is adequate means for cooling the metal surface. Such equipment is made by Surface Combustion Corp., Ipsen Industries, Inc., and General Electric Co.

Class II forms a fog or dew by sudden expansion of a compressed gas sample. It is portable, manually operated, and results are noted visually. Special requirements are a stabilized temperature of instrument, and conversion tables for the type of gas being analyzed. It is manufactured by Illinois Testing Laboratories, Inc.

Class III measures the change in resistivity of a salt compound as the moisture varies. It is affixed to a panel and operates automatically, either indicating, recording, or controlling. It needs special equipment for controlling the temperature of the gas being tested and of the detecting chamber. It is made by Foxboro Co. and American Instrument Co.

Evidently, dew-point equipment is available in a variety of forms from the simple and inexpensive hand-operated dew-point cup to a fully automatic and relatively costly controlling system. Their advantages or disadvantages as applied to particular needs should be thoroughly investigated by the ultimate user.

Regardless of manner in which dew points are measured or controlled, it must be remembered that the ultimate purpose is to perform an essential duty *within a heat treating furnace.* It serves no useful purpose to check dew points religiously if their true relationship to the work to be done has not been established or understood.

General Precautions for Dew-Point Reading

Regardless of the type or application, there are certain precautions which must be observed in using a dew-point instrument.

1. The gas should be drawn from a location which will insure a true sample. If taken from an endothermic generator it should be where freshly generated gas is flowing. (A sample from a dead end of a manifold may easily give an erroneous reading.) If the sample is taken from the furnace it should come from a point well inside the heating chamber and in close proximity to the work.

2. Sampling tubes should be of a heat resistant alloy and of small diameter. Low-alloy steel, copper or iron tubing can result in errors due to gaseous reduction of pipe scale or to catalytic effects. The tube should extend well inside the furnace wall.

3. A suitable filter (of glass wool or other water-impervious materials) should protect the instrument from contamination by dust, carbon and heavy hydrocarbon vapors.

4. A positive displacement pump is recommended for withdrawing gas samples from furnace chambers. For manually operated dew-point indicators, an aspirator bulb or hand pump may be substituted.

5. Flow of gas to the dew-point instrument should be sufficient to insure complete purging of lines and instrument before reading.

6. A minimum of rubber tubing should be used and care should be taken to purge for a sufficient time to dry out this tubing thoroughly.

7. All permanent lines carrying gas samples should be blown out at regular intervals to remove dust or other foreign accumulations.

8. The instrument should be regularly inspected in accordance with the manufacturer's instructions.

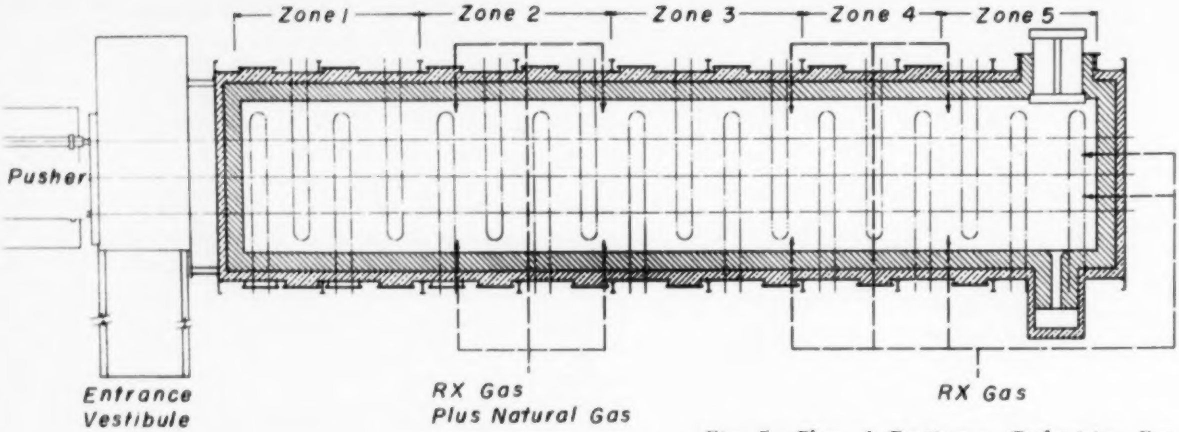


Fig. 5 – Plan of Continuous Carburizing Furnace Showing Method of Introducing Prepared Atmosphere for Carburizing Plus Diffusion Cycle Into Various Zones Along the Furnace Length

Utilization in Industry

Metallurgists have not been backward in recognizing the advantages of carbon control. In the carburizing field, it is very seldom that reference is not made to the *range* of surface carbon expected and required on heat treated work. These carbon ranges are usually well below saturation values for austenite, and, therefore, would present some serious problems in production if carbon potential could not be readily controlled.

For some uses, present-day requirements are so rigid that carburizing atmospheres must never produce hypereutectoid composition at the steel surfaces. For such work little more can be done than to establish dew points in equilibrium with the maximum carbon allowable and then maintain this dew point throughout the furnace during the entire carburizing cycle. The one disadvantage of this practice is a low carbon gradient throughout the entire carburized case.

Fortunately, the great majority of carburizing jobs are not limited by these restrictions, and the ultimate in controlled conditions can be established wherein carburizing rates and case gradients approach theoretical values. Either high-carbon or low-carbon surfaces can be produced without sacrificing these advantages.

These practices are comparatively simple when carbon is controlled by dew point. For example, Fig. 4 shows four actual case gradients, and the caption explains how maximum surface carbon and required hardenable depth can be achieved economically by a combined cycle—first carburize in atmosphere of high carbon potential and then soak in one of low carbon potential.

The use of dew-point measurement has proven to be invaluable in setting up the carbon control of atmospheres required to successfully practice the above principles of gas carburizing. By no other means has it been found possible to determine carbon potential within very close limits.

In batch furnaces, dew points taken at regular intervals determine the amount of enriching hydrocarbon gas (if any) that is needed at that particular time during the carburizing cycle. In continuous gas carburizing furnaces, as shown in Fig. 5, dew points taken in the various zones along the length of the furnace can indicate the amount (if any) of enriching gas required at any time in that zone. By proper manifolding of atmosphere gases to the furnace zones the amount of enriching gas can be independently controlled. The furnace shown in Fig. 5 required only two manifolds to maintain a carbon saturation cycle followed by diffusion. By correctly establishing the dew point of the endothermic ("RX") gas at the generator, correct furnace dew points were maintained by introducing this gas alone in End Zones 4 and 5 while enriching it with natural gas in Zone 2. The resulting dew points throughout the length of this furnace were controlled at about +10° F. in Zone 2, +18° F. in Zone 3, and +30° F. in the discharge Zones 4 and 5.

Such control has been successfully maintained manually with samples analyzed at frequent intervals with a dew-point cup, or from recorder readings. Most recently, all measurements and adjustments to a 4-zone continuous gas carburizing furnace are being taken care of by an automatic multistation recorder and controller.

Carbo-Nitriding

*By HAROLD N. IPSEN**

Carbo-Nitriding: A process in which a ferrous alloy is case hardened by first being heated in a gaseous atmosphere of such composition that the alloy absorbs carbon and nitrogen simultaneously, and then being cooled at a rate that will produce desired properties.

The above definition is the one approved by the Joint Committee on Definitions of Terms, and is in the list on p. 3 of Metals Handbook, 1948 Edition. It is a process which has grown vastly in popularity in the last decade, yet there is still a lot about it that the scientists cannot explain. In practice, the atmosphere flowing through the furnace and around the hot work is a well-prepared endothermic gas to which are continuously added correct amounts of methane (for the carburizing medium) and ammonia (for the nitriding medium).

This process has also been called "nitrocarburizing", "dry cyaniding" and "gas cyaniding". Carbo-nitriding imparts a hard case to steel which provides resistance to metallic and abrasive wear and to corrosion, and increases its strength. It competes with carburizing, liquid cyaniding and, to a lesser extent, with nitriding. Carbo-nitrided parts generally are those which require light to medium depths of case, 0.003 to 0.025 in.

Here are the advantages of carbo-nitriding over light case carburizing or hardening:

First, cheaper steels can be used since the nitrogen absorbed, in conjunction with the absorbed carbon, lowers the critical cooling rate of the steel. Thus the hardenability and uniformity of the carbo-nitrided case are greater. Another saving is that the cheaper steels are generally more economically machined or formed.

Second, carbo-nitrided parts have better wear characteristics.

Third, improved dimensional stability results from cases with lower critical cooling rates and lower transformation temperatures. Both reduce the necessity for a drastic quench, and often eliminate straightening and final grinding.

Carbo-nitriding has these three advantages over cyaniding or liquid carburizing:

First, it is much cheaper.

Second, it can be more accurately controlled, automatically or manually.

Third, it minimizes rusting. Carbo-nitrided parts have been stored for months without any special coatings or oils.†

The reluctance of certain industries to utilize these advantages has been due to a misrepresentation of the so-called "white layer" or skin (plus some retained austenite in the case). These are as easy to control as in a carburized case if we regard nitrogen as an alloying element promoting austenite formation, and then consider the same factors which influence the amount of retained austenite present in a carburized case when direct quenched:

*President, Ipsen Industries, Inc., Rockford, Ill.

†P. A. Clarkin and M. B. Bever of the metallurgical faculty, Massachusetts Institute of Technology, have studied the relative corrosion resistance of carbo-nitrided and carburized steels in salt solution and in sea water. A summary of their work was crowded out of this issue, but will appear in *Metal Progress* next month.

Fig. 1 – Continuous Carburizing Furnace. Courtesy Holcroft & Co.

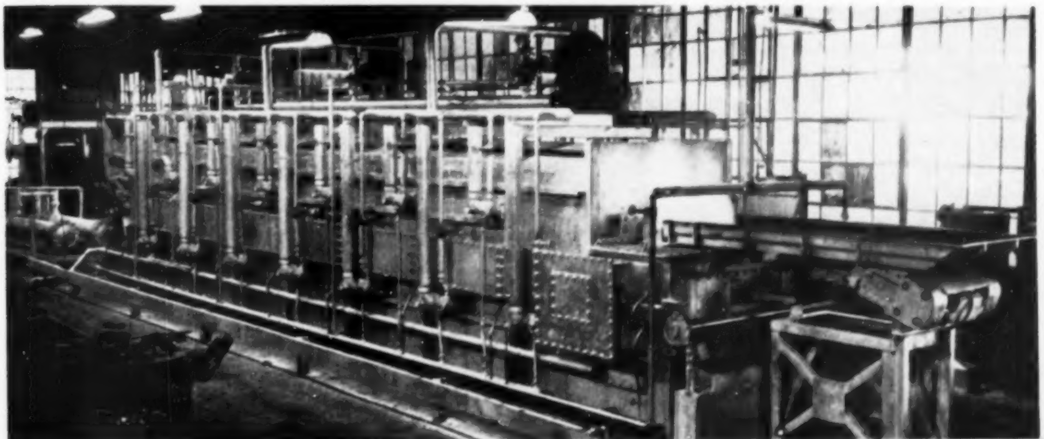
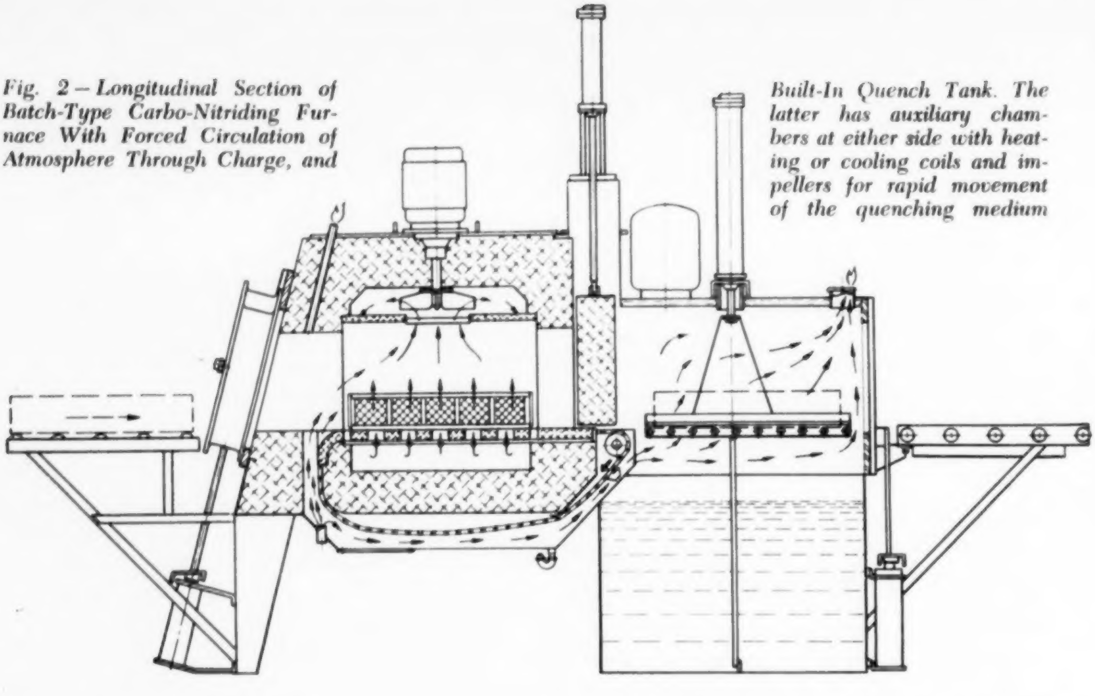


Fig. 2 – Longitudinal Section of Batch-Type Carbo-Nitriding Furnace With Forced Circulation of Atmosphere Through Charge, and Built-In Quench Tank. The latter has auxiliary chambers at either side with heating or cooling coils and impellers for rapid movement of the quenching medium



First, the amount of alloy.
Second, the carbon potential.
Third, the quenching speed.
Fourth, the quenching bath temperature.

The amount of nitrogen is that which will just give the hardenability required to quench out the case. This means careful control of the furnace atmosphere and processing cycle. Wide variations in the amount of ammonia recommended are chiefly due to differences in design and construction of manufacturers' units. Excess ammonia is often added to furnace atmospheres to correct for faulty equipment or atmosphere, as it will increase the hydrogen content of the furnace atmosphere to counteract an excess of water vapor or hydrocarbon gases, and prevent sooting. However, this is a poor way to control nitrogen or carbon in the case!

Thus the advantages of carbo-nitriding can be lost unless the equipment gives uniform heating, uniform atmosphere distribution, and uniform quenching. The equipment components must be designed so that the atmosphere is easily controlled, otherwise carbo-nitriding will be erratic and unacceptable.

Many American furnaces meet these stringent requirements. There are four basic types:

1. Continuous furnaces with belt hearth, often loaded automatically by a vibrating hopper – popular for high production of medium and large parts (see Fig. 1).

2. Continuous furnaces with pusher, loading work in trays. This and the previously mentioned type may be heated with radiant tubes or electrical resistors.

3. Shaker-hearth furnaces, especially suited for very small or light parts, often with automatic loader and a continuous quench belt.

4. Batch furnaces, usually consisting of a heating zone, cooling chamber and an oil quench, all sealed under a protective atmosphere. With a dense load, the atmosphere must be circulated vigorously by fans, built into the roof (see Fig. 2). They are highly versatile and can process small, medium or large parts.

After heating and soaking, the work is preferably transferred under sealed conditions to a quenching device and either slow cooled or lowered for oil quenching, all under atmosphere. Quenching of densely loaded parts is as important as the heating. Oil should be driven *through* the load for uniform and fast cooling of all parts. To reduce distortion to a minimum, quenching oils may be held between 300 and 400° F. as desired.

The composition of the carbo-nitrided case can be controlled by controlling the gas either manually or automatically. The amount of carburizing gas and ammonia used to enrich a given quantity of protective atmosphere (normally endothermic generated gas) is set by valves at a central control panel. Periodic dew-point measurement of the atmosphere within the furnace insures proper operation and results.

Neutral Heat Treating

*By A. W. FRANK**

The prevention of any chemical reaction on the surface of metal being heat treated has been a long-sought objective, but has been realized only recently with the use of furnace atmospheres that are free of oxygen-bearing gases and moisture. Considerable economies are possible with such atmospheres.

Although the term "neutral heat treating" is relatively new, this method has always been the ultimate goal in hardening and annealing operations. Neutral heat treating may be defined as a heat treatment during which no chemical reactions take place on the surface of the metal being treated; the only change effected is in the mechanical properties of the metal.

Neutral heat treating involves the carefully combined use of (*a*) controlled atmospheres, (*b*) furnace equipment and (*c*) exact operational technique. Each factor is of equal importance in relation to final results.

Early attempts at neutral heat treating emphasized exact operational techniques and were mainly based on the theory that free oxygen was necessary for the oxidation of a metal. The possibility of reaction between metal and the oxygen-bearing gases, such as carbon dioxide and water vapor, was not considered. With the improvements in gas-fired furnaces of the muffle type as well as in electrically heated furnaces, studies of atmospheres rapidly brought understanding of the effects of the various gases on metal surfaces during heat treatment.

The constant improvement in furnaces and atmosphere generators over the past 20 years has resulted in highly automatic equipment, which has reduced the need for exacting technique on the part of the worker.

For example, 20 years ago a leading manufacturer of padlocks evolved the following procedure for hardening the small springs used in his product. The springs, of S.A.E. 1090 steel, approximately 1 in. long by 3/32 in. wide and 0.020 in. thick, were carefully stacked in 6-in. deep pots. The container was filled with charcoal, covered with a lid and loaded in a furnace heated to approximately 1425° F. After 2½ hr. in the furnace, the pot was removed and the contents dumped into oil. If the operator was not very adept in performing this operation, very inconsistent results were obtained. Even with good manual operation 100% inspection was necessary because about 5% of the treated parts were inferior.

This operation was not improved upon until a small shaker-hearth furnace was installed in 1951. The new furnace is similar in design to earlier furnaces of this type, except that the muffle is stationary and the reciprocating drive mechanism is connected to the hearth plate and heating elements installed around the quench-chute in such a manner as to eliminate a tem-

After receiving a B.A. in chemistry from Carroll College in Waukesha, Wis., Mr. Frank studied metallurgy at the University of Wisconsin Graduate School. He has been with Hevi Duty since 1937, starting as laboratory assistant and serving successively as service engineer, Chicago district manager, director of research, and chief engineer in charge of research and engineering.

A. W. Frank

*Chief Engineer, Hevi Duty Electric Co., Milwaukee, Wis.

perature drop near the end of the hearth plate. Dissociated ammonia, enriched with natural gas in the correct proportion to give the proper carbon potential, is used as a neutral atmosphere.

An automatic loading device feeds parts from a hopper to the hearth plate. Each spring is in the heated zone for a minimum length of time and is quenched individually to assure maximum physical properties. With the old pot and charcoal method, it took 16 hr. to treat 80 lb. of springs; now it takes 1¼ hr. Also the need for 100% inspection and subsequent cleaning operations has been eliminated while the total cost of hardening has been reduced 75%.

Another example of the modern use of neutral atmosphere equipment is in the annealing of weldments on stainless steel aircraft turbines. In one plant a 30-in. diameter turbine wheel is welded to a 6-ft. shaft. The welds are annealed after inspection, finish machined, and the assembly is given a final inspection for soundness. The assembly is worth about $8000 at this stage and those with faults are scrap unless they can be rewelded, machined and then annealed without distortion or surface change. They cannot be remachined at any points other than at the repaired welds.

This neutral atmosphere annealing of repaired assemblies is performed regularly in a standard atmosphere pit furnace measuring 3 ft. in diameter and 7 ft. deep in the retort. An atmosphere of 85% nitrogen and 15% hydrogen is passed through a chemical drier and into the retort to maintain a pressure of approximately 3 in. of water column. After holding at 1650° F. for 1 hr. the charge is furnace cooled to 350° F. There is no change in the surface condition and the reclaiming of rejected assemblies is nearly 100%.

Neutral heat treating may be performed in many ways, on many materials and for many purposes. Many atmospheres may be used, such as dissociated ammonia, mixtures of bottled gases or atmosphere from generators. The best selection of this combination requires careful study.

Sintering

*By CARL G. PAULSON**

The bonding of the individual particles during the sintering operation is dependent not only on temperature but also on the proper furnace atmosphere for that temperature. Although the volatile constituents of the binding material are driven off at relatively low temperatures, the chemical reaction of the residue with certain gases rids the compact of these materials to permit the particles to establish a bond with each other.

SINTERING is the process of applying heat to powder metal compacts to obtain desired physical properties; these properties are determined by the powders used, how they are proportioned and mixed with the lubricants, and by the pressure used in compacting. The sintering operation purifies the compact and raises its temperature to the point where recrystallization between particles forms a common bond and establishes a new identity without going through a liquid phase.

The compact consists of fine particles of powder which, after pressing, are held together by their interlocking surfaces. Between and around the metal particles there are lubricating constituents of some sort and possibly volatile substances, each of which has been added for a definite purpose, but is not wanted in the finished product. To obtain a bond between the surfaces

*Service Manager, C. I. Hayes, Inc., Cranston, R.I.

of the individual metal particles, these extraneous substances must be removed, as must any occluded gases trapped in the pores or formed as coatings on the surface of the metal. This is one of the functions of the sintering operation. Early attempts at driving off lubricants and volatiles in separate ovens with forced-air circulation resulted in uncontrollable firing because at approximately 600° F. spontaneous combustion occurred. The entire process from preheating to sintering and cooling must take place in a controlled atmosphere.

The sintering process, therefore, involves a furnace with a preheat section, a high-heat section, a cooling chamber and the necessary atmosphere generator. As the green compacts enter the preheat chamber a heavy black smoke is evolved as the temperature begins to drive out the volatiles (by the pressure of the expanding gases). It is important in some types of work that most of these volatiles be driven out during the low-temperature cycle because in the early stages the action begins gradually and all pores are open to allow gases to escape freely. By the time the compact is in the high-temperature zone it will have cleared itself, through chemical reaction with surrounding atmosphere, of most of the carbonaceous volatiles. The furnace atmosphere then penetrates the pores and starts cleansing the inner surfaces. The reactions that take place at these two latter stages depend on the type of powders being used. The nonferrous powders require temperatures up to 1600 or 1700° F., while the iron powders are usually treated in the range of 2000 to 2250° F.

The behavior of oxygen - hydrogen - carbon reactions under conditions where the oxygen supply is not sufficient to satisfy both the hydrogen and the carbon reaction varies with the sintering temperatures. Such a condition might be represented by an atmosphere containing no free oxygen but small amounts of hydrogen, carbon monoxide, carbon dioxide, methane and moisture. The reactions of such an atmosphere at the lower temperatures (1000 to 1700° F.) favor hydrogen as the active member, but at high sintering temperatures the carbon is more reactive. As temperature increases, hydrogen releases its bid for the scant supply of oxygen, even to the extent of giving up what it holds in a combined state (for example, $H_2O + C \rightarrow CO + H_2$). In addition, similar dissociation occurs with the carbon-hydrogen molecule ($CH_4 + H_2O \rightarrow CO + 3H_2$). If the oxygen supply is available only as CO_2, the other carbon particles present (residue in the compact) will share this supply as follows: $CO_2 + C \rightarrow 2CO$. Therefore, the purification of the core of the compacts during sintering in a medium to high temperature range should be done in an atmosphere containing carbon dioxide.

If the temperature is raised to the range of 2000 to 2250° F. the CO_2 releases some of its oxygen to the iron of the compact. Since this causes scaling of the compact, the atmospheres for this range of temperatures must be free of CO_2 and the water vapor content must be reduced to a predetermined dew point to control the carbon potential. In a few applications where dense, hard structures are required and where the compact contains ingredients representing a 1% carbon steel, the atmosphere must be capable of protecting the compact against decarburization. It may be well to note that the possibilities along this line are greater than normally supposed. For instance, when the proper mixture of powders is employed and the proper compacting pressure used, a sintering operation at 2250° F. can produce dies which, when coined and then heat treated like a normal piece of steel, will have a hardness of Rockwell C-64, and serve as well as their counterpart of regular steel. This method of fabrication is suited for small and intricate dies required in great numbers. When compacts of this composition are heated at

(*Continued on p.* 176)

Graduating as an electrical engineer from University of New Hampshire (1915), Carl Paulson started his career as a service and later sales engineer for Westinghouse. He came to C. I. Hayes in 1928 as an electrical and mechanical engineer, was assigned to sales and service work within a year, and ten years later was appointed service manager and placed in charge of research and development. He is in charge of the Hayes laboratory.

Carl G. Paulson

An International Atomic Agency*

THE PEOPLE of the United States believe wholeheartedly in the purposes and the principles set out in the Charter of the United Nations. That document marks a milestone in an understanding of the nature of peace. It recognizes that peace is not merely a passive concept, but peace is a call to action.

Mankind will never have lasting peace so long as men reserve their full resources for tasks of war. To preserve peace and to do so without the sacrifice of essential freedoms, require constant effort, sustained courage and at times a willingness to accept grave risks. That is the true spirit of peace.

The past year has been marked by intensive efforts in the field of atomic energy. The United States has sought to share its commanding position in this field in ways which would permit many to join in a great new adventure in human welfare. [To that end, on] Dec. 8, 1953, President Eisenhower proposed that the nations possessing atomic material should cooperate under the auspices of the United Nations to create a world atomic bank into which they would each contribute fissionable material, which would then be used for the purposes of productivity rather than of destruction.

So the United States, after consultation with others, prepared and submitted [to the Soviet Foreign Minister] a concrete, detailed proposal. We hoped and believed that the Soviet Union would join with other nations.

The plan we submitted could not have hurt anyone. Its initial dimensions were not sufficient to impair the military capacity of the Soviet Union. Above all, it was a practical, easily workable plan, not dependent upon elaborate surveillance.

Nevertheless, the proposal was, in effect, rejected by the Soviet Union last April. The Soviet position was to say "we will not cooperate to develop peacetime uses of atomic energy unless it is first of all agreed that there should be renunciation of all uses of atomic energy", including the uses which provide the free nations with their strongest defense against aggression.

The United States, of course, remains ready to negotiate with the Soviet Union. But we are not ready to suspend longer our efforts to establish an international atomic agency, to explore and to develop vast possibilities for peaceful uses. Our efforts have been and will be directed primarily toward the following ends:

1. The creation of an international agency, whose initial membership will include nations from all regions of the world, and it is hoped that such an agency will start its work as early as next year.

2. The calling of an international scientific conference to consider this whole vast subject, to meet in the spring of 1955, under the auspices of the United Nations.

3. The opening early next year, in the United States, of a reactor training school where students from abroad may learn the working principles of atomic energy with regard to its peacetime uses.

4. The invitation to a substantial number of medical and surgical experts from abroad to participate in the work of our cancer hospitals in which atomic energy techniques are among the most hopeful approaches to controlling this menace to man.

I want to make it perfectly clear that our planning excludes no nation from participation in this great venture. As our proposals take shape, all nations interested in participating and willing to take on the responsibilities of membership will be welcome to join with us in the planning and the execution of this program.

Even though much is denied us by Soviet negation, nevertheless much remains that can be done. There is denied the immense relaxation of tension which might have occurred had the Soviet Union been willing to begin to cooperate with other nations in relation to what offers so much to fear, so much to hope. Nevertheless, there is much to be accomplished in economic and humanitarian ways.

There is no miracle to be wrought overnight. But a program can be made and vitalized to assure that atomic energy can bring to millions a better way of life. To achieve that result is our firm resolve.

DISARMAMENT—Closely allied to this question of the peaceful uses of atomic energy is the whole vast and complex question of disarmament.

At this Assembly last year the United States affirmed its ardent desire to reduce the burden of armament. We participated in discussions with the Soviet Union, the United Kingdom, France and Canada to find out whether a fresh approach to the problem could achieve a solution acceptable to the Soviet Union as well as to the free world. The record of these metings has now been made public.

It shows that the representatives of Canada, France, the United Kingdom and the United States tried with patience and with ingenuity to explore all avenues of agreement with the Soviet Union which would be consistent with the security of all nations. Once more we made clear, as we have again and again in the past, that we seek to eliminate the use of atomic energy for any purpose other than those of peace.

These efforts were met by flat refusal by the Soviet Union even to discuss our proposals on their merits. The crux of the Soviet position was that, before it will engage upon real negotiations on disarmament, it insists upon a paper ban by the major powers of all use of nuclear weapons. The great shield, the supreme deterrent, must first be abandoned, leaving the free nations exposed to the Communists' unrivaled manpower. Once that inequality has been assured, then — perhaps — the Soviet Union will negotiate further from its then gained position of assured supremacy.

Such procedure would not increase the security of any free nation.

Reluctantly, we must conclude that the Soviet Union has no present serious desire to negotiate on the disarmament problem.

* Verbatim excerpts from address to United Nations General Assembly, Sept. 23, 1954, by John Foster Dulles, Secretary of State, U.S.A.

The third round-table discussion sponsored by the Industrial Heating Equipment Assoc. at the A. S. M. National Metal Congress (Chicago, Nov. 3) concerned recent improvements in equipment and new applications for induction heating. Four papers on induction heating in forge shops will appear next month. Use of high-frequency alternating currents for heating metals was originally proposed in 1917 by the eminent physicist, Edwin F. Northrup of Princeton University, and a year later was utilized commercially by Handy & Harman for melting silver. Not until 1935 was the first unit for surface hardening of steel sold by Ohio Crankshaft Co. So heat treating with induced electrical energy is just now coming of age.

Induction Heat Treating

*By HARRY B. OSBORN, JR.**

Case histories are cited indicating a trend in induction heating toward ingenious fixtures for handling the work, often automatically, through cycles which produce selectively hardened areas to close specification. Costs are often cut further by using alloy and more readily machinable steel than required for older heat treating processes.

HEAT TREATING with induced electrical currents – "induction heating", for short – has been continually expanding because industry has been faced with rising labor rates, increased material costs, and keen competition. In numberless instances, induction heat treating equipment has cut labor costs, cut material costs, and increased production of a higher quality, thus meeting competition and widening markets.

There is little reason in this place to describe the fundamental idea. It is too well known to metallurgists. Nor is there reason to develop the mathematical equations showing the relationships between current characteristics, nature and size of the part being treated, and time. Certain general conclusions bear repeating. They are models of simplicity:

The higher the frequency, the shallower the depth.

The longer the time, the greater the depth.

The higher the power density (kilowats per sq.in. of surface), the shorter the heating time and the shallower the depth of hardening.

Of course, these simple statements should be modified by considering the metallurgical structure of the part being heat treated. Assuming, however, reasonable *response* of the structure (no long heating time and no excessive temperature required) 30 to 35 kw-sec. per sq.in. of surface area processed is recommended. There are also minimum practical diameters and thicknesses of stock where, regardless of frequency or power, a thin surface could not be hardened. For example, the surface of a 0.10-in. round could not be heated shallow enough or fast enough to prevent through hardening.

In view of the expanding nature of my subject, I have considered it best to treat it by citing a number of case histories drawn from records of several manufacturers of induction heating

*Technical Director, Tocco Div., Ohio Crankshaft Co., Cleveland.

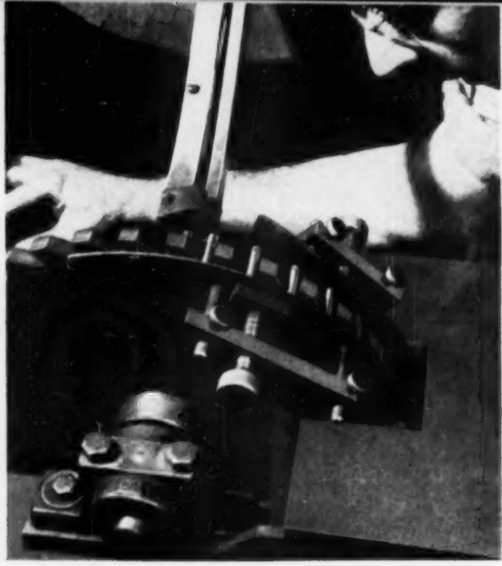


Fig. 1 – Notches on Rim of Slowly Moving Wheel Are Automatically Filled With Hardened Pins; Induction Coils at Right Soften the Ends. Courtesy Westinghouse Electric Co.

equipment.* Except where a reference to frequency is made for a specific purpose, I have given only the power rating of the equipment. Many heating jobs can and are being done with more than one frequency. For surface hardening, manufacturers have standardized on the following frequencies for minimum case depths:

*Editor's Note – Twenty-eight in the original presentation. The version here printed was necessarily confined to a few typical illustrations.

3,000 cycles per sec.	0.060 in. case (min.)
9,600	0.040
450,000	0.020

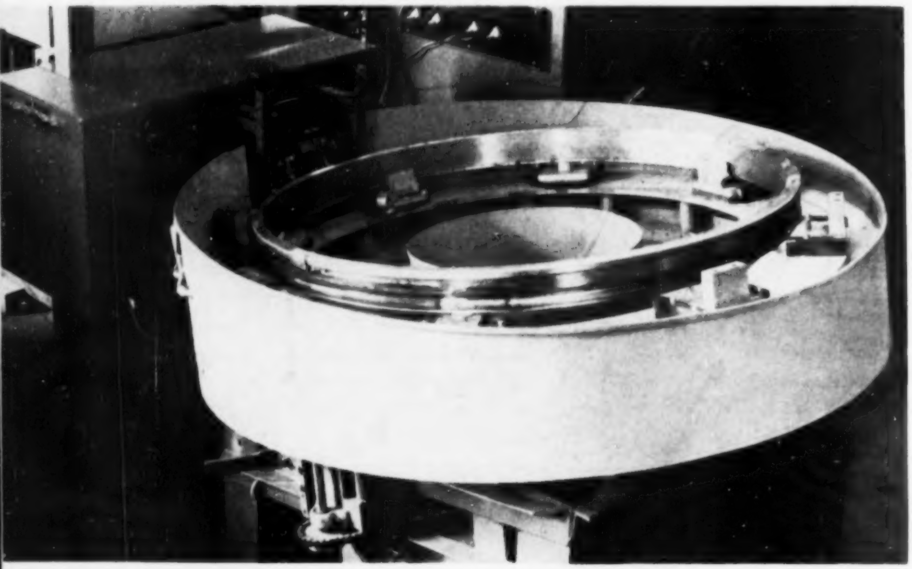
In production these shallow case depths are rarely achieved except with material which has been given a prior heat, quench, and draw. Depths in production jobs usually run from 0.050 to 0.150 in., regardless of frequency, and depend on the material being hardened, its prior heat treatment (if any), its physical dimensions and configuration, and the power density.

Little and Big

To contrast the *size* of work which can be handled, Fig. 1 shows small pins and Fig. 2 a tank turret foundation.

The small items are pins for sprocket chains – hard for wear against links but soft at ends for upsetting on assembly. An automatic feeder delivers them one at a time into the notches of the circular transporter which moves them between appropriate induction coils which reheat the ends properly. Prior to the use of this device, they had been hand dipped one end at a time in a lead pot. Full-time skilled labor has been replaced with part-time unskilled. One operator working part-time turns out ten times the old production rate. Many other views could be given of fixtures for mass production. These fixtures, of course, are built appropriately for each job. Nevertheless, handling devices of this sort are characteristic of many of the latest applications of induction hardening – the process itself is almost ideally suited to give the ingenious equipment designer full sway.

Fig. 2 – Machine for Progressive Hardening Raceways on Tank Turret Parts to C-55 to 60. Courtesy Induction Heating Corp.



Contrast this to the raceway for a tank turret, Fig. 2. The outer surface to be hardened has a profile that practically eliminated flame hardening as a possibility. A 50-kw., 450,000-cycle induction heating unit continuously heats and quenches to a depth of 0.090 in. and hardness of C-55 to 60. The part shown is 30 in. in diameter, but the same technique is used on all sizes of races up to a large 8-ft. unit. Due to the accurate metallurgical con-

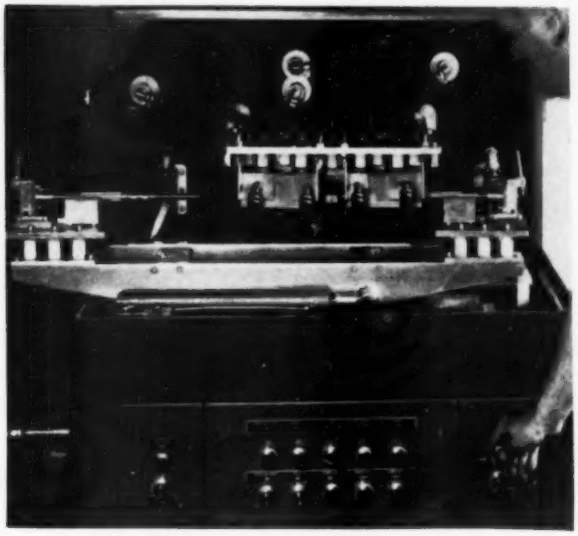


Fig. 3 – Machine for Hardening (and Drawing Back Slightly) an Appropriate Length of Spline and Bearing. One starter shaft is in fixture at left while operator unloads fixture at right

trol, there is only ⅛-in. overlap when the full circumference is completed, and a drop in hardness of 5 points in this region.

Here is an example of where increased production and lower cost were important, but the vital factor was that of quality. The elimination of distortion produced a part which was unobtainable any other way unless a scrap loss approaching 70% could be endured. All of the larger races and many of the small ones are processed on 10,000-cycle equipment.

Selective Hardening

Next will be cited instances of induction heat in its earliest use – you might almost say, traditional use – namely, hardening of given areas on a single part.

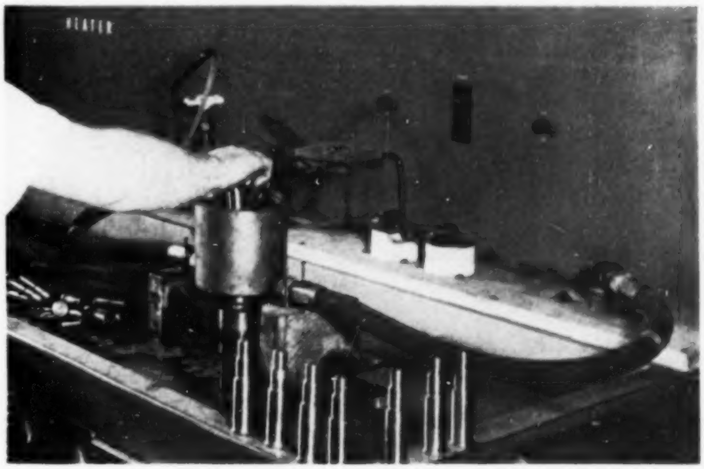
First is a sewing machine part – a plain shaft with a bell crank on one end. Ends of the shaft are to be hardened, in addition to the inside shoulder of the bell crank. Prior to induction hardening, the parts to be soft were copper plated, and the rest carburized. Unit operations for 100 pieces were:

Mask and put on plating racks	23.0 min.
Copper plate crank end	43.0
Remove from plating racks	15.0
Harden shaft and anneal crank	120.0
Strip lead	10.0
Strip copper and clean	33.3
Total for 100 pieces	244.3 min.

Now, with a 20-kw., 450,000-cycle generator equipped with vertical scanning fixture, the 244.3 min. is reduced to 92.5. All operations listed above are eliminated with the exception of hardening and annealing, now done with induction and in even less time. A saving of 151.8 min. per 100 parts has cut the hardening time 62%.

A much more intricate part, previously selectively carburized and hardened, or heat treated and selectively annealed, is now handled by induction at a substantial saving. This is the automotive starter shaft shown in the fixture at the left of Fig. 3. It is made of C-1141 steel, and the major diameter is approximately ¾ in. A case depth of 0.150 in. is produced selectively in two areas and to a hardness of C-45 (achieved by automatically drawing back from C-53). This dual treatment is applied to a 1¼-in. length on the spline and a ½-in. section of the bearing. The fixture is double-ended, air operated, reciprocating, and moves horizontally. The operator loads one side while the fixture has indexed a part that has been previously loaded on the other side.

Fig. 4 – Coupling Bolts Economically Surface Hardened, Electrically, Rather Than Carburized, Quenched and Tempered. Courtesy General Electric Co.



Finally are coupling bolts, which with similar parts were formerly batch carburized. Now, by selective hardening, production has been increased 50% and hardening costs reduced 70%. A three-day furnace cycle is reduced to a few seconds in the machine shown in Fig. 4. Accurate positioning for hardening assures uniformity of results without distortion. Further, parts may be completely machined from soft stock and induction hardened for final operation.

Continuous Versus Intermittent Hardening

It is necessary, of course, to have an induction coil which encloses the whole area to be hardened; a long piece can be drawn at correct speed end to end through a collar-like coil, a ring around the surface heated and immediately spray quenched.

Figure 5 shows such a machine for handling simultaneously six axleshafts. Depending on diameter and requirements in the finished part, either 3000 or 10,000-cycle equipment is used.

With increased demand for more horsepower in the automotive and truck industry, the transmission system must be stronger than ever. In this system, the axleshaft is one of the most important parts.

Conventional practice has used alloy steels, heat treated to medium hardness range and then machined. With induction heating, however, we can reduce the alloy requirement – often even eliminate it. The shaft is machined in the soft condition (some just as forged and not even annealed) and then progressively surface hardened end to end, including the flange fillet if so desired.

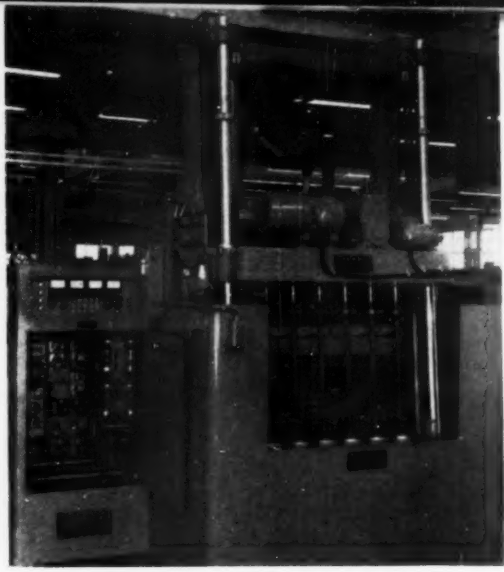


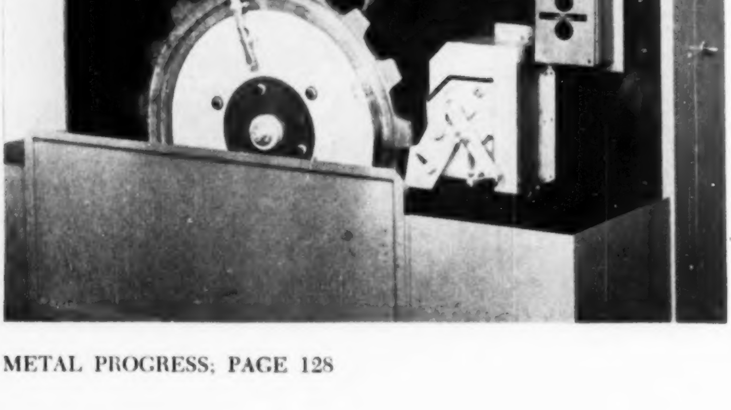
Fig. 5 – Standardized Tocco Machine for Hardening Six Axleshafts Simultaneously, End to End. Note electrical devices in open control cabinet at left

Such shafts are as much as 200% stronger in torsional strength, and anywhere from 15 to 45c per shaft cheaper.

A battery of four continuous hardeners has been notably successful in heat treating bar stock at Caterpillar Tractor Co.'s Peoria Works. These induction heat treaters, with feed and run-out tables, heat, quench, and draw each bar uniformly as it passes progressively along. Stock sizes range from ½ to 2½ in. diameter. Each unit usually heat treats 250 lb. of bar stock per hr., the bars being heated uniformly throughout to 1575° F., quenched, and then drawn at desired temperature (approximately 1000° F.) to a controlled microstructure. Hardness is held to within one point Rockwell-C.

Such bars, because of good and consistent machinability, have increased production of automatic screw machines as much as 40%.

Fig. 6 – Method of Hardening Sprocket Gears, Tooth by Tooth. Courtesy Induction Heating Corp.



However, continuous operation is unnecessary. Witness the sprocket gear shown in Fig. 6. Many gears are hardened with high power and all the teeth heated at one time, but generally the requirements and the production runs are such that the cost of such an installation would not be justified. This "tooth at a time" technique has proved very popular, therefore. Further, the lower costs of operation and more uniform results have replaced many flame hardeners.

In Fig. 6 we are processing a 26-in. diameter sprocket in a rather novel set-up. Two 25-kw. generators and two heating coils are used simultaneously. A total of 25 sec. per tooth is needed for heating and quenching to harden the sides of one tooth and the adjacent root.

The gear teeth are indexed individually and locked into position. The coils are then lowered manually over the teeth and the hardening cycle started by pushbutton.

Finally, let me cite an instance which forecasts a new move into the coming age of automation – namely machining and heat treating in one operation.

For almost any part which now is produced, or which can be produced, on a multiple-spindle automatic, and which requires selective heat treating, it is only necessary to reserve one spindle on the automatic for the induction coil and the heat treating operation.

The surface treated may be either internal or external. An example of the latter is a vane pump shaft, and an example of the former is an automotive trunnion cup. Frequently, the part can be made of S.A.E. 1144 steel, and eliminates costly copper plating and carburizing for differential heat treating by the older methods described in the first two sessions of this conference.

Visualize these installations wherein bars are fed into a machine and a completely machined and heat treated part is automatically discharged from the final station!

Book Review...

Rare Metals *Reviewed by BRUCE A. ROGERS**

THE METALLURGY OF THE RARER METALS; 156 p. Institution of Metallurgists, London, or Penton Publishing Co., Ltd., London. 1953. 15s 6d.

PRESUMABLY, the task of a reviewer is to provide enough information for a potential reader to estimate whether the book is likely to be helpful to him. The reviewer must ask himself what the hypothetical reader will wish to know. Obviously the *subject* of the book is of major importance; the reader will wish to know with what region of knowledge it is concerned, and also, in how much detail it covers that region; he will be interested in learning whether the author has treated the subject in a way that fits his needs. For example, is the subject presented in too elementary or too advanced a manner? Is the book unsatisfactory in any other way? Is

*Senior Metallurgist, Ames Laboratory, Institute for Atomic Research, Ames, Iowa.

it written in a style easy to read? Finally, can the reader depend on the accuracy of the book?

An idea of the contents of the book may be gained by listing the headings of the eight chapters (actually lectures) contributed by eight well-known British metallurgists. Each chapter heading begins "The Metallurgy of . . ." The metals described are uranium, beryllium, molybdenum, tungsten, titanium and zirconium, tantalum and niobium (columbium), chromium and manganese, and the platinum metals. The inclusion of the million-tons-per-year metals manganese and chromium is a little astonishing, and one wonders what justification can be given for it. The author of the chapter says that "it is only when one attempts to obtain relatively pure manganese or chromium in any fabricated form that one begins to see the justification for this classification". Unalloyed, workable manganese and chromium might well have been classified with the nonexistent rather than the rarer metals at the time this book was written, but since then the U. S. Bureau of Mines has produced chromium at least that is amenable to fabrication in the cold state.

Each author has followed a general outline in covering his respective metals – first, a brief history of the discovery of the metal, then, the nature and location of the ores, the methods of extraction, the reduction to metal, the properties of the elemental metal, its fabrication, applications, and a brief description of the principal alloys. Since the average length of a chapter is 19 pages, only the most important facts can be presented. As might be anticipated, the emphasis upon each of the different parts varies considerably according to the technology of the metal and the interest of the author. For example, about 80% of the chapter on beryllium is concerned with extraction and reduction to the metal; the chapter on molybdenum is weighted about as heavily in favor of properties, fabrication and applications. The writer of the chapter on uranium obviously was handicapped by the requirement of secrecy.

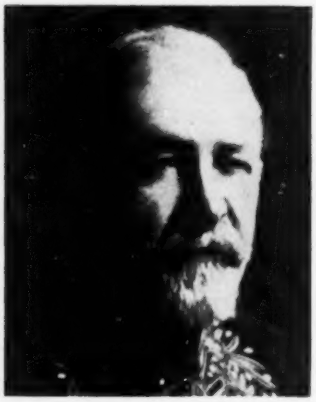
The title page states that this book constitutes a "refresher course". Presumably, it is intended for men whose formal education is wearing a bit thin under the erosion of daily activities. However, it should be valuable also for men who are making their first contact with metallurgy. Although almost every chapter can be understood by a sophomore science or engineering student, this book is interesting to the more advanced reader as well. This reviewer enjoyed all of it. It is one of the most interesting and least tedious books likely to be found on a metallurgical subject. Perhaps one of the reasons for this is that the authors are able to outline the important facts without introducing cluttering details. This type of writing means, of course, that the qualifying details must be sought elsewhere. An example is a statement that 2% manganese lowers the ductile-brittle transition in a 0.05% carbon steel (iron-carbon alloy) from +80 to −65° C. Little hint is given concerning the complicating effects of minor alloying additions and heat treatment upon this behavior of manganese.

When one considers the editorial work and the factual accuracy of "The Metallurgy of the Rarer Metals", one's enthusiasm lessens. It seems to contain an unusual number of typographical mistakes, improperly balanced equations and other errors. Furthermore, the references could have been presented in a more readable form. The inclusion of an iron-molybdenum diagram that is considered outdated in the United States may be an editorial error, an author's mistake, or perhaps an actual difference of opinion.

This reviewer is doubtful concerning the statement "The characteristic behavior of the body-centered cubic and hexagonal metals as the testing temperature is reduced is the transition from the tough to the brittle condition within a narrow temperature range, indicated by a large decrease in energy absorption accompanied by cleavage fracture." Regarding this ductile-brittle transition in body-centered cubic metals, there are sufficient data to start speculation, but the case is by no means proven. The evidence for a ductile-brittle transition in hexagonal metals is much less convincing. Upon reading this statement, this reviewer experimented on both iodide zirconium and iodide titanium wires by bending them sharply with pliers while they were immersed in a flask of liquid nitrogen, and found that they behaved in much the same manner as when bent at room temperature. This experiment certainly is less conclusive than an impact test at the same temperature, but other reports say that iodide titanium does not show a ductile-brittle transition down to liquid nitrogen temperature. Furthermore, magnesium alloys have been tested down to −180° C. (−292° F.) without showing a sharp transition.

In spite of the shortcomings mentioned above, most of which may well be due to the very brevity of the work, "The Metallurgy of the Rarer Metals" will be an informative and useful reference book in any metallurgical library.

Personal Mention



Albert M. Portevin

ALBERT PORTEVIN, distinguished French physical metallurgist, has been made an honorary member of the American Society for Metals. The author of more than 350 papers and a long-time contributor to *Metal Progress*, he heads the editorial committee of the *Revue de Métallurgie* and is a member of the editorial committees of various other technical magazines. He is president of the board of directors at the Ecole Supérieure de Soudure Autogène, professor and president of the Development Council of the Ecole Supérieure de Fonderie, president of the French Association for Testing Materials and of the International College for Scientific Study of Techniques and Mechanical Production, president of the International Commission for Testing of Cast Iron. Professor Portevin has received eight honorary degrees; he is a grand officer in the French Legion of Honor, one of the highest awards accorded by the French government; he is one of the few members of the French Academy of Sciences ever to be unanimously elected; he holds the Osmond Medal, the Seaman Medal, the Transenster Medal; he is the only scientist ever to hold at once the platinum medal of the Institute of Metals in London and the Carnegie and Bessemer Medals of the British Iron and Steel Institute.

Bradley Stoughton

BRADLEY STOUGHTON ⊕ past president, who has not been far from the academic field since he was named assistant to Henry Marion Howe at Columbia University 57 years ago, has been accorded an honorary membership in the American Society for Metals. He was awarded his doctorate at Lehigh University in 1896, where he later became head of the department of metallurgy, a position he occupied with distinction until his retirement. During his later years at Lehigh, he also served as dean of the College of Engineering. Dr. Stoughton was elected secretary of the American Institute of Mining and Metallurgical Engineers in 1912, and remained in that office for ten years. He was president of the Electrochemical Society in 1931. In 1930, he was elected treasurer of the American Society for Metals, becoming vice-president in 1940 and president in 1941. In 1951 he conducted one of the study tours for the World Metallurgical Congress. In 1939, the Lehigh Valley Chapter ⊕ established an Annual Stoughton Night, and, in 1943, the Bradley Stoughton Award for outstanding contributions to metallurgy by a member of the Chapter. Dr. Stoughton is the author of "The Metallurgy of Iron and Steel" (1908), and with Allison Butts co-authored "Engineering Metallurgy" (1926).

A. P. Ford

Metal Progress was four years old and carrying some 29 advertising pages a month when PETER FORD arrived on the job in November 1934. Even though he has lived in Cleveland since 1927, he still considers himself a Hoosier, and has a warm spot for Fort Wayne, where he finished high school and business college before moving to Ohio. Previous to joining the ⊕ staff, he worked for some years in the public relations department of the famed Van Sweringen interests.

For the first three years Pete remained in the headquarters office, handling *Metal Progress* advertising from source to printer, seeing other printing and production jobs through the works, learning about ⊕ structure and services, and generally steeping himself in Society activities. In 1937, with the groundwork thus thoroughly laid, he was assigned the area from Pittsburgh to Chicago, and took to the road with the purpose of convincing potential advertisers and Metal Show exhibitors that the members of the American Society for Metals are the most important market in the world for those who wish to sell the metal industry. Since that time he has worked practically every part of the United States, and in 1945 was named sales manager, covering the country with the able assistance of district managers in New York, Cleveland and Chicago.

Marking his 20th anniversary with ⊕ next month, he can look back over the years of steady growth from the 29 advertising pages of 1934 to today's average of about 160 per

(Continued on p. 134)

Revere Extruded Shapes help increase ELECTRIC GENERATOR OUTPUT

(perhaps you, too, could use our shapes to your advantage)

Model section of G.E. direct-cooled rotor for turbine-generator. Note intake scoop at left front, hollow copper conductors of extruded shapes, in center, exhaust outlet at right rear.

Insert shows typical extruded shapes after milling by G.E. to provide circulation of hydrogen throughout the field coils.

Winding temperatures are an important limitation upon the output of electric utility generators. They must be kept within safe limits to avoid damaging the insulation. Hence all generators have some method of cooling. Conventionally, the heat passes from the copper conductors in the rotor, through the insulation (which presents a formidable barrier to heat transfer) to the steel parts of the rotor body, and air or hydrogen is pumped through and around the rotor. It was realized long ago that more effective cooling could be obtained if some way could be found to remove the heat directly from the rotor coils.

Some years ago generator engineers of the General Electric Company, Schenectady, New York, proposed making each turn of the rotor coils of two copper extruded shapes; one a channel, the other comb-like. Fitted together, they would make hollow passages for the hydrogen, which would be taken in through scoops on the surface of the rotor, and exhausted through outlets some distance away, also on the rotor surface. In that way, the rotor could be quite uniformly and more effectively cooled throughout its length, and output greatly increased in relation to the physical dimensions of the generator.

An important problem was found in the extruded shapes. Design requirements had to be adjusted to the opportunities and practicalities of the extrusion process. Today these copper shapes, 20 feet long, drawn and finished to strict specifications as to dimensions and straightness, are making it possible to remove four times as much heat as conventional systems, and to double the generator output with no increase in size ... For full information on extruded shapes, see the nearest Revere Sales Office.

REVERE

COPPER AND BRASS INCORPORATED

Founded by Paul Revere in 1801

230 Park Avenue, New York 17, N. Y.

• • •

Mills: Baltimore, Md.; Chicago and Clinton, Ill.; Detroit, Mich.; Los Angeles and Riverside, Calif.; New Bedford, Mass.; Rome, N. Y.—Sales Offices in Principal Cities, Distributors Everywhere.

SEE "MEET THE PRESS" ON NBC TELEVISION, SUNDAYS

Personals . . .

(Continued from p. 132)
month. Nevertheless, Pete doesn't like the word "sell" because he doesn't believe anyone is ever "sold". He believes that you must find out what the prospect wants and give that prospect sufficient reason to make him want to buy. Ideas are the most important product a salesman can have – and friends. Pete has plenty of both.

Gerald Abowitz is studying for a Master's degree under the Campbell Fellowship at Columbia University.

William A. Holt has joined the industrial heating department of the Canadian General Electric Co., Ltd., Toronto, Canada.

Edward A. Sprigg, formerly manager of the Orange Plant of Breeze Corporations, Inc., has been transferred to headquarters engineering division in Union, N.J., as chief engineer. He joined Breeze Corporations in 1949 as project engineer.

William F. Kramer has been transferred to the main office of the Pure Oil Co. as chief inspector and assistant manager in the refinery technical department.

John J. Carroll, formerly metallurgist, Ford Instrument Co. Div. of Sperry Corp., is now process engineer for Grumman Aircraft Corp., Bethpage, L.I., N.Y.

Richard A. Burkett has a new position as sales and field engineer for Penn Precision Products, Inc., Reading, Pa., a firm specializing in rolling beryllium copper and other alloys to close tolerances and thin gages.

W. D. Becker, long a member of the staff of Burns and Roe, Inc., engineering consultants, has formed his own group, W. D. Becker & Associates, Marine City, Mich. At Burns and Roe Mr. Becker was a piping specialist, in charge of high-temperature, high-pressure power plant piping design, including associated metallurgical and corrosion problems.

Lester F. Spencer, formerly of Pratt & Whitney Aircraft Div., Hartford, Conn., as process engineer, is now with the Naval Research Laboratory, Ferrous Alloys Branch, Washington, D.C., as metallurgist.

Stephen M. Toy is now a research associate at Ohio State University.

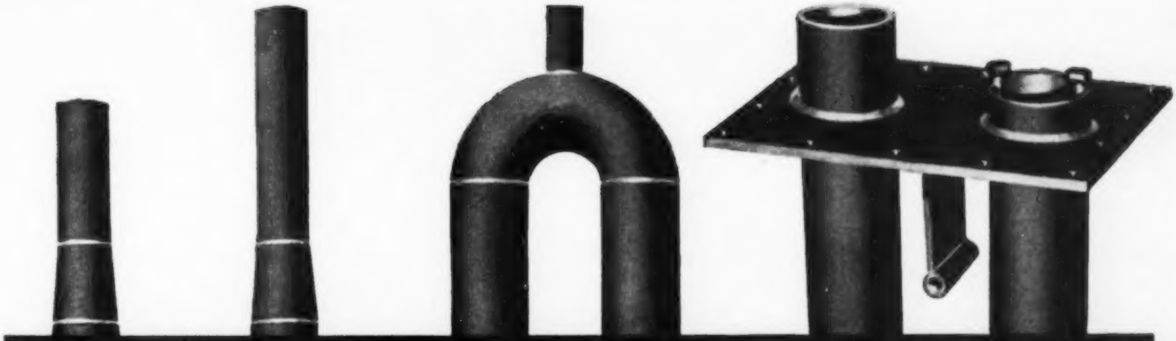
James A. Krimian is now with Packard Motor Car Co. as chemical engineer. For 21 consecutive years he was with Murray Corp. of America as chemist, materials engineer, chief chemist and laboratory supervisor. He received his B.S. in Chemical Engineering from Michigan State College in 1931.

H. D. Sturgis has been promoted to assistant manufacturing manager of the Wright Aeronautical Div. of Curtiss-Wright Corp. in charge of jet and reciprocating models.

Ira S. Young is now metallurgist at the Downey, Calif., plant of North American Aviation, Inc.

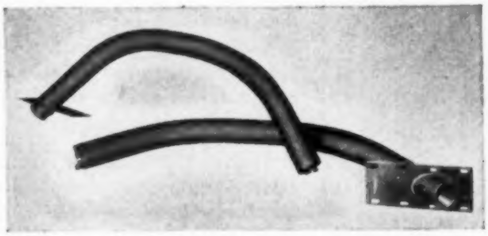
Frederick E. Johnson Colorado School of Mines, 1954, is with the Hanford Atomic Products Operation of General Electric Co. as technical graduate, rotational trainee.

Robin O. Williams has joined the staff of the General Electric Research Laboratory in Schenectady, N. Y.

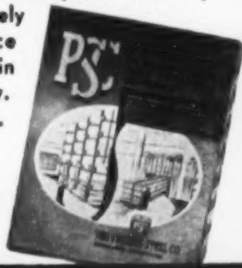


'PSC' RADIANT TUBES in *Any Design or Dimension*

The increasingly wide adoption of PSC "Thin-Wall" radiant tubes by furnace builders is based on three impressive advantages: (1) Their light-wall, sheet alloy-construction saves both furnace time and fuel. Being 33 to 50% lighter than cast tubes, they cut initial cost and handling time. (2) Return bends are fabricated to give uniform wall thickness throughout, promoting uniform flow of gas. (3) Because their smooth dense walls minimize carbon build-up and consequent burn-out, PSC tubes are setting entirely new standards for service life. Precision-assembled in any size, shape or alloy. Write as to your needs.



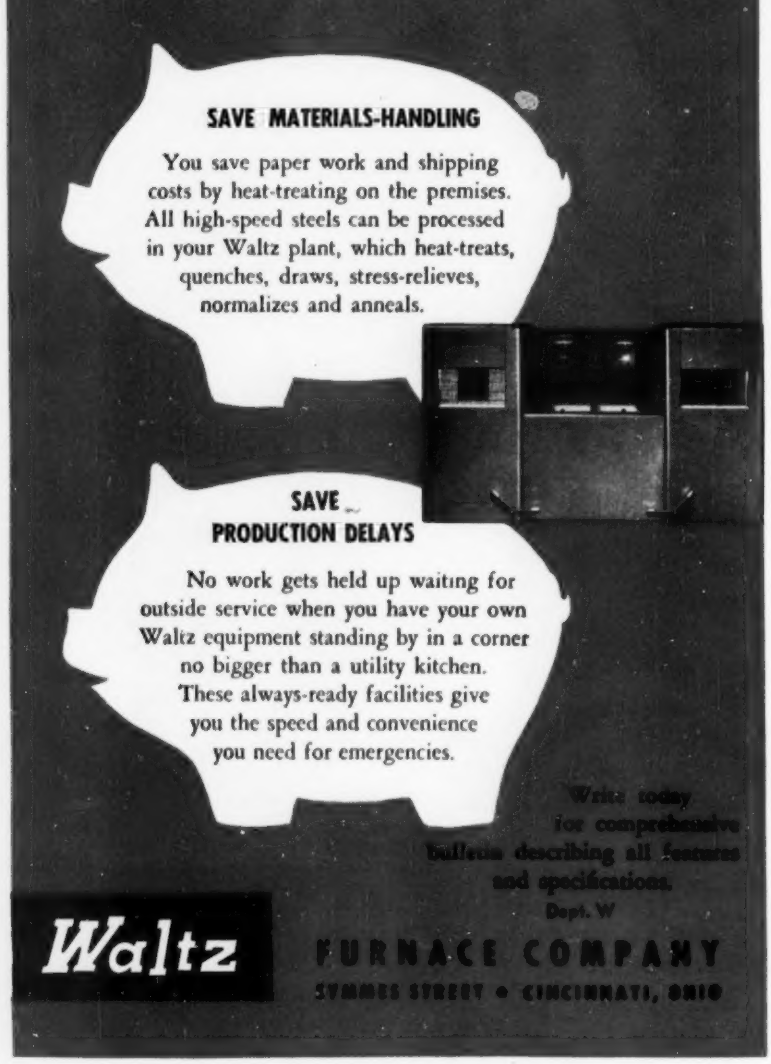
Send for
HEAT-TREAT CATALOG



THE PRESSED STEEL COMPANY
of WILKES-BARRE, PENNSYLVANIA

Industrial Equipment of Heat and Corrosion Resistant WEIGHT-SAVING *Sheet Alloys*

☆ ☆ ☆ OFFICES IN PRINCIPAL CITIES ☆ ☆ ☆



Personals . . .

Paul M. Leininger, formerly assistant professor of chemistry at Lafayette College, is now associate professor of chemistry at Albright College, Reading, Pa.

A. S. Cogan has been appointed engineering development manager, ammunition research, Arms and Ammunition Div., Olin Industries, New Haven, Conn.

Richard E. Stoll has been transferred to the research laboratory of U.S. Steel Corp. at Kearny, N.J., for a period of one year, after which he will return to the South Works of the Corporation.

Alexander Zekany has left Rohr Aircraft Corp. at Chula Vista, Calif., to take a position as research engineer with North American Aviation, Inc., in Columbus, Ohio.

Leon H. Nelson (a member of the Executive Committee of the Calumet Chapter) has been appointed director of conservation and field control for the various plants of Crucible Steel Co. of America. He had previously been with the Buffalo and Chicago districts of Republic Steel Corp. in openhearth, metallurgical, conservation and quality control activities.

Forrest B. Fuller has retired after 34 years in research and development in aeronautical materials for the U.S. Air Force, Wright Field, Dayton, Ohio.

Thomas A. Read has left Columbia University to become professor of metallurgy and head of the department of mining and metallurgical engineering at the University of Illinois.

C. Marvin Wayman, who completed a two-year tour of duty with the U.S. Air Force in June, during which time he was engaged in titanium research at Wright Air Development Center, Wright-Patterson Air Force Base, is now in graduate school at Purdue University, studying metallurgical engineering.

Walter R. Smalley has transferred from the South Philadelphia, Pa., works, aviation gas turbine division of Westinghouse Electric Corp., to the Kansas City, Mo., works of the same division.

Personals . . .

Charles H. Pitt is at present an engineering assistant with the Army Medical Research Laboratory, Fort Knox, Ky.

Robert A. Huggins, formerly an instructor in the department of metallurgy at Massachusetts Institute of Technology, has accepted a position as assistant professor of metallurgy in the School of Mineral Sciences, Stanford University.

Robert B. Green has been named head of the physical research department of Baker & Co., Inc., Newark, N. J. Dr. Green was formerly an associate professor of physics at Stevens Institute, where he helped establish a solid state group. Previous to that he was an assistant professor of mechanical engineering at Massachusetts Institute of Technology. He received his B. S. degree from Princeton University and the Sc.D. from the Massachusetts Institute of Technology.

Edwin W. Earhart, formerly metallurgical engineer with Alan Wood Steel Co., Conshohocken, Pa., is now superintendent of metallurgy with the Lone Star Steel Co., Dallas, Texas.

Geoffrey E. Brock, an August '54 graduate from Pennsylvania State University with a Ph.D. in metallurgy, is associated with the New Jersey Zinc Co. of Pennsylvania as metallurgical investigator in products application.

Warren P. Chernock, formerly senior metallurgical engineer with the atomic energy div. of Sylvania Electric Products, Inc., Bayside, L. I., N. Y., is now senior scientist in the crystallographic group, physical properties section, physical chemistry department of the general research organization of Olin Industries, Inc., of New Haven, Conn.

Curtis M. Jackson, a graduate of New York University in June '54 with the degree of Bachelor of Metallurgical Engineering, is now a member of the staff of the alloy development division of the metallurgy department at Battelle Memorial Institute, Columbus, Ohio.

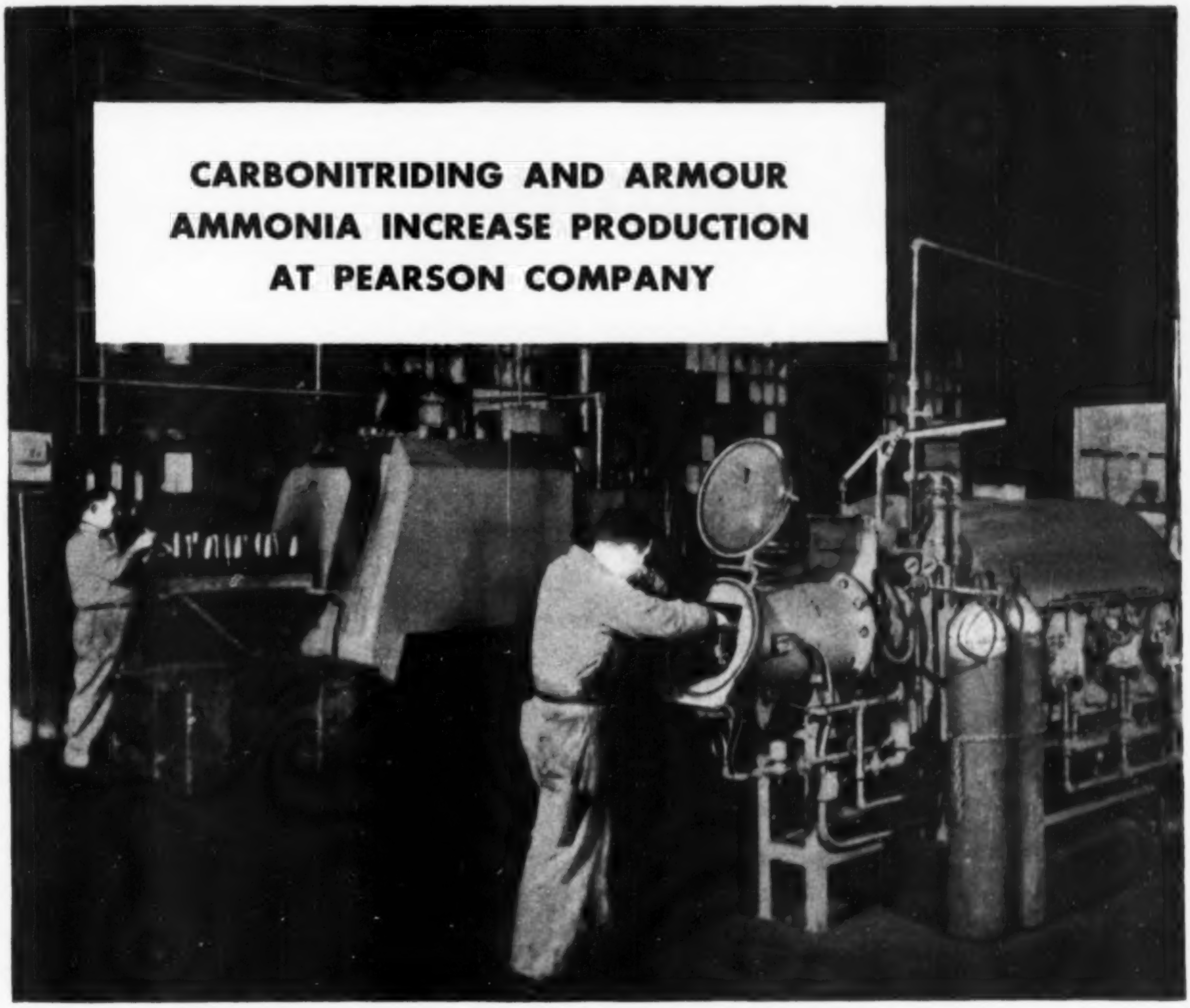
Fred K. Landgraf, Jr., formerly a metallurgical service engineer with the pig iron division of Republic Steel Corp., has recently been placed in charge of pig iron sales for the Chicago sales office.

L. C. Mitchum, formerly lubrication engineer, is now supervising lubrication engineer for the State of Alabama for the Texas Co., with headquarters in Birmingham.

William F. Klenk has enlisted in the U.S. Air Force for a period of two years as an Airman Third Class, and is working in the metals laboratory in the steel and welding branch at Wright Air Development Center, Wright-Patterson Air Force Base, Ohio.

Desle O. H. Miller has accepted a position as sales engineer with the Chicago Rawhide Mfg. Co., working out of the Peoria, Ill., district sales office.

William A. Mays, formerly metallurgical engineer with the U.S. Bureau of Mines, Amarillo, Texas, has accepted a position as research engineer with the North American Aviation Corp., Los Angeles.



New processes prove more efficient, safer for metal treating

Those carbonitriding and brazing furnaces above mean greater production and safety at the Pearson Industrial Steel Treating Company in Chicago. And Pearson specifies Armour's pure, dry ammonia and dependable service for their carbonitriding.

All through the metal treating field, plants are using every improved process they can to provide their clients with better work. Since many of these new processes require ammonia, more and more companies like Pearson are calling on Armour ammonia and service for best results.

Carbonitriding has reduced costs and increased safety in many plants. And Armour men were there in many cases to give advice and help on installations. Those men in Armour's Technical Service Department are equipped and ready to help you in your installation.

Since 1947 Armour has sponsored a fellowship at the Massachusetts Institute of Technology for the study of carbonitriding and other modern metal treating processes. That knowledge is basic research, and available to you.

The booklets offered below will show you how to put this knowledge to work in your plant. Write today for free copies. If your ammonia problem is unusual or pressing, write us giving full details of your requirements.

Clip and mail this today!

☐ "Applications of Dissociated Ammonia"
☐ "Ammonia Installations for Metal Treating"
☐ "The Nitriding Process" ☐ "Carbonitriding"

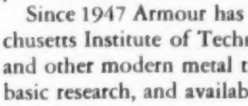
Name________ Title________

Firm________

Address________

City________ Zone____ State________

P11



Save money on our tank truck delivery service available in most areas

ARMOUR *Ammonia Division*

Armour and Company • 1355 West 31st Street • Chicago 9, Ill.

Personals . . .

Charles K. Leeper is employed as senior engineer with Nuclear Development Associates, Inc., White Plains, N. Y.

Arthur F. Hallam, formerly metallurgist with Clevite-Brush Development Co., Cleveland, has accepted a position as physicist for Firestone Tire & Rubber Co., Akron, Ohio.

Louis F. Roth, formerly metallurgist with Deere & Co., Moline, Ill., is now employed as a metallurgist at Russell, Burdsall & Ward Bolt and Nut Co., Rock Falls, Ill.

Harold A. Kahler, formerly eastern district representative for Poor & Co., Chicago, is now assistant to the vice-president of the Promat Division of the company.

D. I. Sinizer, formerly with Arthur D. Little, Inc., Cambridge, Mass., is now project manager in the metallurgical department at National Research Corp. in the same city.

Albert David Rossin entered Massachusetts Institute of Technology following graduation from Cornell University in June 1954, and is attending the M.I.T. Oak Ridge School of Engineering Practice in Tennessee, and is studying for the degree of master of science in nuclear engineering.

Charles E. Sallade is now employed at Frankford Arsenal, Philadelphia, as metallurgist in the industrial service section of the artillery department.

Walter E. Jones, formerly a metallurgist in Thomson Laboratory of General Electric Co. at Lynn (Mass.) River Works is now manager, vacuum melted products engineering, Carboloy Dept., Detroit.

Irving Rozalsky, formerly research associate at Case Institute of Technology, from which he obtained the Ph.D. degree in June 1954, is now employed as metallurgist in the Wood River, Ill., research laboratory of Shell Oil Co.

Alfred Strasser has resigned as metallurgist at Wright-Patterson Air Force Base to become metallurgist for Nuclear Development Associates, White Plains, N. Y.

Personals . . .

C. M. Davis, formerly plant metallurgist at the Litchfield, Ill., plant of the American Radiator & Standard Sanitary Corp., has accepted a position as metallurgist with South Gate Aluminum and Magnesium Co., South Gate, Calif.

W. Sansom is now employed as district sales manager in the newly opened Montreal office of Vanadium-Alloys Steel (Canada) Ltd., covering Quebec and the eastern provinces.

E. M. Doss is now employed by the Aerojet-General Corp., Azusa, Calif., where he is attached to the materials engineering department.

Willard O. Cook has transferred his interests from steel to farming following retirement from United States Steel Corp. after 37 years of service. Mr. Cook held the position of research associate and was mainly concerned with the quality study of hot-dipped and electrolytic tin plate.

J. V. Houston, Jr. has been transferred by the American Brake Shoe Co. to Duluth, Minn., to open a sales and service office serving mining companies. Mr. Houston holds the title of manager, iron range development.

K. L. Keating has resigned from the staff of Stanford University, where he was an instructor in metallurgy, to join the technical staff of Bell Telephone Laboratories in Allentown, Pa.

E. H. Babcock has accepted a position as senior metallurgist with Consolidated-Vultee Aircraft Corp., Pomona, Calif.

N. F. Ward is now chief materials and process engineer and head of materials and process control division of aero engineering at the U. S. Naval Air Faculty, Litchfield Park, Ariz.

R. C. Waugh, who graduated in metallurgical engineering from Cornell University in June 1954, has accepted a position as junior metallurgist at the Oak Ridge National Laboratory, Oak Ridge, Tenn.

W. J. Herten is employed as process engineer by Rheem Mfg. Co. in the aircraft div. at Downey, Calif.

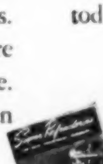
Silicon carbide skids replace chrome hearths in seven furnaces, and give . . .

3 Times the hearth life

This forge furnace is one of seven operated by a well-known automotive company. In four of these they heat 16-lb steel slugs to 2250 F, pushing through about 250 slugs every hour. In the others they heat 6-lb billets. All seven furnaces originally had rammed, chrome-ore hearths, but the wear and tear was much too severe. The hearths constantly needed repairs. And in less than three months, they'd be worn out.

Today, all these furnaces have silicon carbide skid rails. These average *nine months' life,* and require few repairs between times. That's only one third as many replacements as formerly required; one third the labor; and one third the downtime.

Figure the total savings! They're sizeable enough to make anyone check for possible applications for our refractories. The easiest way: leaf through "Super Refractories in Heat Treatment Furnaces"—40 easy-to-read pages of picture-caption case histories. Your type of furnace is undoubtedly shown. Write for your copy today. No obligation, of course.



CARBORUNDUM

Registered Trademark

Dept. C-114, Refractories Division
The Carborundum Co., Perth Amboy, N. J.

Please send free booklet to:

NAME ______ POSITION ______

COMPANY ______

ADDRESS ______

Personals . . .

Henning Klouman ⊕, formerly with Michiana Products Corp., Michigan City, Ind., is now foundry manager, Lakeside Div., Bendix Aviation Corp.

Charles C. Eeles ⊕ has been transferred by the Ohio Fuel Gas Co. from Toledo to Columbus, Ohio, where he is assistant industrial and commercial sales manager.

Charles E. Martin ⊕ is teaching machine shop in the industrial arts department at Rocky Mountain College, Billings, Mont.

Charles E. Peterson ⊕ is now chief metallurgist of Mackintosh-Hemphill Co., Pittsburgh and Midland, Pa., where he has been assigned a major responsibility for the technical phases of producing cast iron and steel rolls, cinder pots and other company products. After serving in the U. S. Navy, Mr. Peterson graduated from Carnegie Institute of Technology with a degree in metallurgy. In 1949, he joined Mackintosh-Hemphill as a metallurgical assistant to the vice-president in charge of research and development, but left the company in 1953 and until his present assignment was a sales and research metallurgist for the rolls division of Blaw-Knox Co.

William O. Wood ⊕ is now a sales engineer with Vanadium-Alloys Steel Co. with headquarters in St. Louis, Mo., after having been associated for four years with the Lindberg Steel Treating Co., St. Louis.

Ned D. Hehner ⊕ has completed work for the M.S. degree in metallurgy at the University of Cincinnati and is now in the U. S. Army at Ft. Leonard Wood, Mo.

Leland F. House ⊕ has been transferred from the materials section of the aircraft nuclear propulsion department, General Electric Co., Cincinnati, to the large steam turbine-generator division, Schenectady, where he is employed as a metallurgical engineer in the manufacturing engineering section.

Stewart W. Sandberg ⊕ has transferred from materials engineering department, metallurgical application section of Westinghouse Electric Corp., East Pittsburgh, Pa., to the development engineering department, aviation gas turbine division of the corporation in Kansas City, Mo.

R. K. Sheetz ⊕, who graduated as a metallurgical engineer from Virginia Polytechnic Institute in June '54, is employed in the metals research division of Olin Industries, Inc., New Haven, Conn.

Edgar Belkin ⊕, a former employee of Westinghouse Electric Corp., Buffalo (N. Y.) Works, as a metallurgist in the copper department, is now employed as a metallurgist at Picatinny Arsenal.

George John ⊕ has been promoted from assistant metallurgist to metallurgist of the foundry division, Textile Machine Works, Reading, Pa.

John G. Frantzreb ⊕, formerly chief metallurgist of J. D. Adams Mfg. Co., Indianapolis, has accepted a position as materials engineer with Caterpillar Tractor Co., Peoria, Ill.

Hugh P. Gibbons ⊕ has joined the Michigan Steel Casting Co., Detroit, as superintendent of research in the metallurgical alloys division.

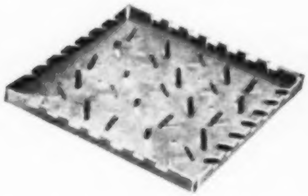
John H. Rizley ⊕ has resigned from the staff of AiResearch Mfg. Co., Phoenix, Ariz., to join the Guided Missile Division of Consolidated Vultee Aircraft Co., Pomona, Calif., as a metallurgist in the process control and reliability department.

Tool Steel Topics

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation. Export Distributor: Bethlehem Steel Export Corporation

LEHIGH H DIE PRODUCES INTRICATE FLOOR-PLATE SECTION



The picture at the upper right shows the business end of a large blanking-and-forming die, used in making floor-plate sections for Flash-Stone Company, Inc., Philadelphia. The photograph below shows 11-gage sheet steel being fed into an 850-ton press, beyond operator, where it undergoes initial blanking and forming. Additional forming, plus trimming, are done in a return pass, at operator's left. Above appears the finished product, an 11¾-in. square, with numerous lugs on the top and sides for gripping the concrete.

The die, made of Lehigh H tool steel, is providing long production runs because of its good resistance to wear and shock. Redressing is seldom required.

Lehigh H is a high-carbon, high-chromium, air-hardening tool steel, well known for its easy machinability and easy heat-treatment. It's a deep-hardening steel, too, with high compressive strength.

TYPICAL ANALYSIS

Carbon	1.55	Molybdenum	0.80
Chromium	11.50	Vanadium	0.40

Like to prove to yourself how Lehigh H Tool Steel wears . . . and wears . . . and wears? Call your tool steel distributor, or write a line direct to us at Bethlehem, Pa.

Sheet steel, being fed into press for initial blanking and forming, is further formed and trimmed on the return pass into the finished floor plate, which is shown on the slide near foot of picture.

BETHLEHEM TOOL STEEL ENGINEER SAYS:

Use Distortion Tests With Care

Distortion of tool steel in heat-treatment is a phase of toolmaking which is often misunderstood. And some of the available distortion-test data adds to the confusion.

Typical of the misleading distortion tests are those on bar stock, about ¾ in. round and 1 in. long. The results are reported as the change in length occurring in the hardening heat-treatment, and certainly do tell what happens when steel of that size is hardened. But how to use this data to predict size changes of tools of other sizes? There's the rub!

The test described implies that the distortion figure for the 1-in. piece can be applied elsewhere—for example, that a 5-in. piece changes 5 times as much, and a 10-in. piece 10 times as much. Not so! Depending on the size and shape of the pieces being hardened, expansion or contraction may occur, but the factor cannot be used to predict which. Therefore the data obtained on the test piece is of limited value, as it applies only to the hardening of tools of the size and shape of the test piece itself. There is no such thing as a single test specimen which predicts size changes in tools of various sizes and shapes.

If you would like additional information on distortion, write for a copy of our article, "Distortion of Tool Steels in Heat-Treatment."

Personals . . .

M. E. Fine is now a professor in the graduate department of metallurgy at Northwestern University.

Pol Duwez, professor of mechanical engineering at California Institute of Technology, has terminated his association with the Jet Propulsion Laboratory and will devote all his time to teaching and carrying out research at the Institute.

Richard W. Wilson, formerly chief metallurgist and assistant foundry superintendent at the American Hoist & Derrick Co., St. Paul, Minn., has been appointed sales engineer with the Electro Metallurgical Co., division of Union Carbide & Carbon Corp., with office in Chicago.

Ward W. Minkler has been transferred to the New York office of Titanium Metals Corp. of America as assistant manager of market development.

Donald W. Hackett, formerly with Globe American Corp., Kokomo, Ind., has been appointed to the staff of the Y-12 Plant, Oak Ridge, Tenn., an atomic energy installation operated by Carbide and Carbon Chemicals Co., a division of Union Carbide and Carbon Corp.

Stephen L. Ingersoll, previously vice-president and treasurer of the Ingersoll Steel Division of Borg-Warner Corp., Chicago, has been promoted to the post of executive vice-president.

M. L. Kaufmann is now vice-president of the Usco Plate Corp., East Chicago, Ind., in addition to being vice-president of the parent company, the United States Reduction Co.

A. A. Archibald has been named vice-president, engineering and plant, for Jones & Laughlin Steel Corp., Pittsburgh. He was formerly vice-president, special products and services, with responsibility for the direction of the wire rope, warehouse, electric weld tube and container divisions. In his new position, he will have administrative responsibility for the engineering division, products development, and plant development. Mr. Archibald joined Jones & Laughlin in 1935 as an assistant in the metallurgical department at the Pittsburgh Works. In 1940 he was transferred to the sales department and was sent to the Philadelphia district office. During World War II, Mr. Archibald was loaned by the corporation to the War Production Board, Steel Division, as a dollar-a-year man. He became assistant to the vice-president, plant development, in 1947, and in 1950 was made director of plant development. In 1952 he was named director of special products and services, and in April, 1954 vice-president.

Ben Ray has been appointed manager of technical field service, industrial chemical sales division of Solventol Chemical Products, Inc., Detroit. He brings to his new position several years experience with Solventol, and prior to that with Chrysler Corp., where he worked on the surface treatment of metals in the metallurgical and processing laboratories. Mr. Ray received his degree in chemical engineering from Wayne University.

Here's how you save

WITH THE

DU PONT SODIUM HYDRIDE DESCALING PROCESS

1. SHORT TIME CYCLE

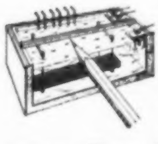
Only 15 seconds are required to get cold reduced-annealed strip clean and bright —10 to 20 minutes for fabricated articles, sheets, wire, rods, bars and forgings. Even heavily scaled forgings (½" scale thickness) take less than an hour!

2. NO LOSS OF BASE METAL

There's no danger of costly rejects due to pitting, etching, or loss of gauge with the Du Pont process—no matter how long work is left in the bath. This permits working to closer tolerances and assures high dimensional accuracy.

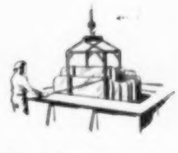
3. RETREATMENTS RARELY NEEDED

One pass through the sodium hydride bath will do the job completely. You can maintain uniform speed in production-line descaling. Quick completion of orders means you can substantially cut down on inventory in process.



4. SIMPLIFIED PROCESS

No scale-breaking or special racking procedures are required. Finished stock of any size or shape can be completely descaled with the versatile Du Pont process. Even dissimilar metals can be treated in the same bath—at the same time!



5. EASY TO OPERATE

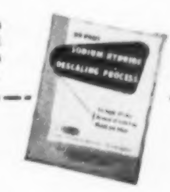
Any pickler can be trained in a few hours to run the Du Pont Sodium Hydride Descaling Process effectively. You can do more work with fewer men and less equipment. And you save on time, space and labor costs.

6. DU PONT TECHNICAL SERVICE

If you are descaling metals which are unaffected by fused caustic at 700°F., it will be to your advantage to talk with us about the Du Pont Sodium Hydride Process. Du Pont pioneered this modern descaling method and can bring a depth of technical experience to bear on your descaling problems. There's no cost for this service which includes laboratory investigation of problems plus expert aid in the construction, installation and operation of the process. Just call our nearest district office or send in the coupon below.

SEND FOR FREE BOOKLET describing the Du Pont Sodium Hydride Descaling Process—how it works—what it can do for you. This illustrated booklet lists the metals that can be descaled with this remarkably efficient process . . . gives brief descriptions of necessary equipment and operating precautions. Just fill out and mail the coupon below for your copy. E. I. du Pont de Nemours & Co. (Inc.), Electrochemicals Department, Wilmington 98, Delaware.

DISTRICT AND SALES OFFICES: Baltimore • Boston Charlotte • Chicago • Cincinnati • Cleveland • Detroit Kansas City* • Los Angeles • New York • Philadelphia Pittsburgh • San Francisco *BARADA & PAGE, INC.



DU PONT
Sodium hydride process for positive descaling

DU PONT

BETTER THINGS FOR BETTER LIVING . . . THROUGH CHEMISTRY

MAIL THIS COUPON FOR FREE BOOKLET

E. I. du Pont de Nemours & Co. (Inc.)
Electrochemicals Department MP-11
Wilmington 98, Delaware

☐ Please send me your free booklet on Sodium Hydride Descaling.

☐ Please have one of your technical men call. I am interested in descaling__________.

*Name*__________ *Position*__________

*Firm*__________

*Address*__________

*City*__________ *State*__________

Personals . . .

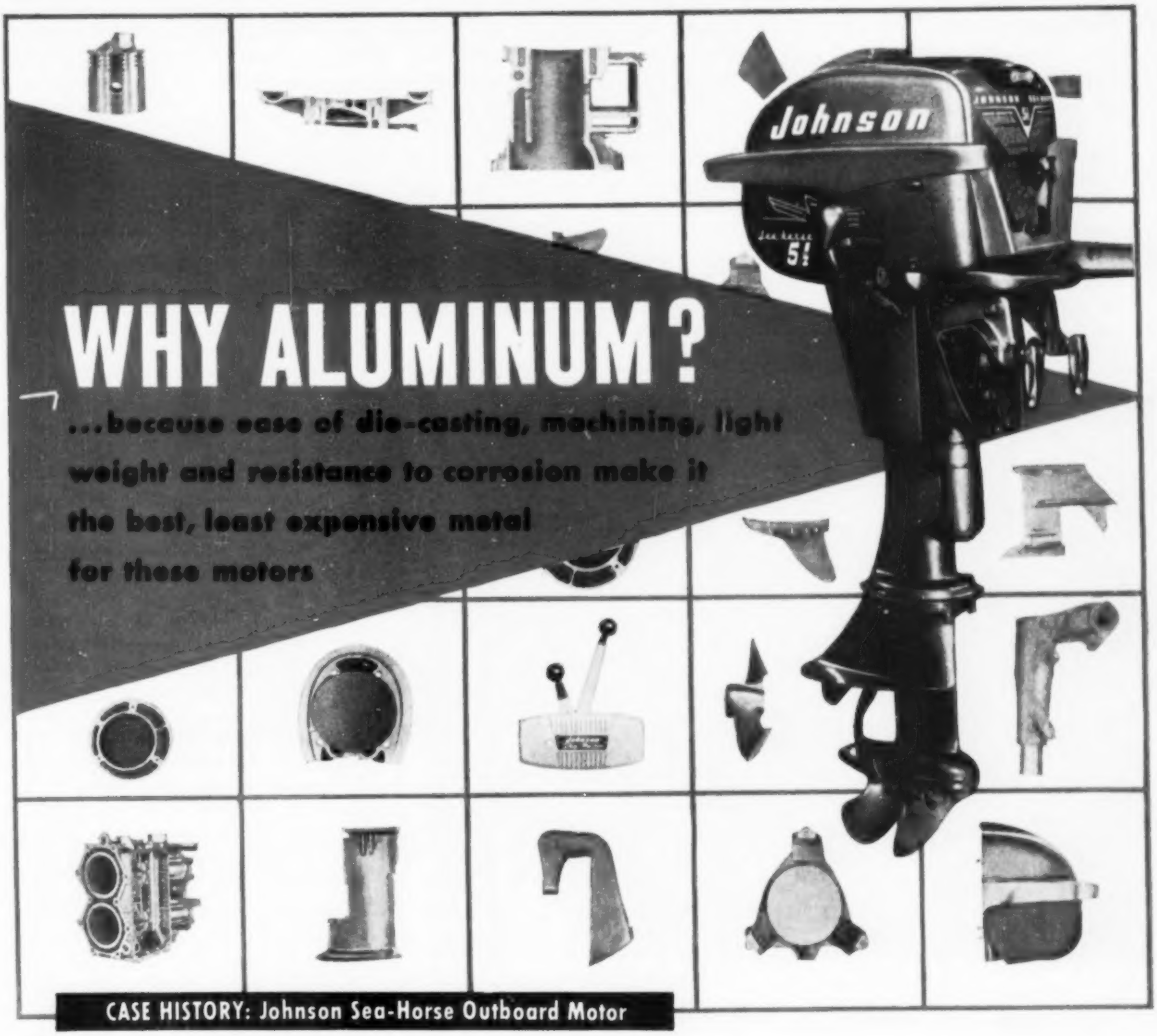
William N. Findley ⊕, formerly of the University of Illinois, has accepted a professorship in engineering at Brown University, where he expects to continue his research on the mechanical behavior of metals and plastics. Professor Findley is setting up a new laboratory at Brown University for fatigue and creep testing.

Hugh (Pat) Gibbons ⊕ has been appointed supervisor of the Rx Met Div., Michigan Steel Casting Co., Detroit. Mr. Gibbons was formerly plant superintendent for the Cannon Muskegon Corp., Muskegon, Mich. Prior to this he was assistant superintendent at the Hillsdale Foundry Co., Hillsdale, Mich. He is a graduate metallurgical engineer from the University of Michigan.

L. C. Schweitzer ⊕, formerly Chicago district manager of the Tocco Div., Ohio Crankshaft Co., Cleveland, has been appointed assistant general manager of the division. Mr. Schweitzer joined Ohio Crankshaft Co. in 1939 after having served as an industrial heating specialist for Westinghouse Electric Corp. He established Tocco's first sales office in Chicago, and served in turn as sales engineer, district sales manager, and, finally, district manager. He holds the degree of B.S. in metallurgy from Carnegie Institute of Technology, and has had 29 years of experience in engineering and sales.

Ranald M. (Don) Garrison ⊕ has been appointed manager of manufacturing for Hanson-Van Winkle-Munning Co., Matawan, N.J. Prior to naval service during World War II, Mr. Garrison worked for nine years as chief engineer, then plant manager of an oil field equipment company. He has bachelor's degrees in electrical engineering from Rice Institute and in mechanical engineering from Cornell University.

Herbert L. Pfaffhausen ⊕ and **John F. Quereau** ⊕ recently observed the 25th anniversary of their employment with Leeds & Northrup Co., Philadelphia, and were presented with 25-year plaques. Mr. Pfaffhausen is sales field engineer in Philadelphia, and Mr. Quereau is production manager.



Advances in Aluminum Die-Casting have opened the door to increased production, lower costs for Johnson. Johnson pioneered the use of aluminum and reduced the weight of outboard motors by 65% with the initial aluminum motor.

Because the outboard motor *must* remain portable, aluminum's resistance to corrosion and the light-but-strong quality prove ideal, give more power-per-pound than any other metal. There are more than fifty-five different aluminum die-castings in the motor shown here.

Aluminum die-castings permit close dimensional control that results in minimum machining. Thin, strong wall sections and intricate contours are made possible. Excellent surface finishes are achieved without grinding or buffing.

You, too, can take advantage of aluminum advantages and also get Reynolds engineering and styling help in the design of your products. Remember—aluminum is light but strong . . . is always attractive (frequently without special finishes) . . . has excellent heat and light reflectivity . . . high electrical and thermal conductivity.

Consult Reynolds Aluminum Specialists on your next design or redesign project. Call the Reynolds Office or Distributor listed under "Aluminum" in your classified directory or write *Reynolds Metals Company, 2519 So. Third St., Louisville 1, Kentucky.*

Designed in REYNOLDS ALUMINUM

Look for this new seal in color on foil identifying products "Designed in Reynolds Aluminum"

See "Mister Peepers", starring Wally Cox, Sunday nights on NBC-TV

REYNOLDS ALUMINUM

MODERN DESIGN HAS ALUMINUM IN MIND

Personals . . .

A portrait of **Clark B. Carpenter** was unveiled at Colorado School of Mines by the Alumni Assoc. at the end of the last school year, together with a bronze plaque commemorating "his 32 years of distinguished service as assistant professor, associate professor, head of the department of metallurgy, and dean of the graduate school". Dr. Carpenter retired a year ago.

Henry A. Holberson has been elected vice-president and general manager of Youngstown Metal Products Co., a subsidiary of the Youngstown Sheet and Tube Co., Youngstown, Ohio. After serving as an instructor in engineering subjects at Youngstown College and Case Institute of Technology. Mr. Holberson joined the company in 1935 as a tool and diemaker. Three years later he became a tool and die designer, an engineer in 1940, and assistant vice-president in 1951.

James G. Sylvester, formerly head, research laboratory division of Mutual Boiler & Machinery Insurance Co., Boston, has announced the establishment of a firm of consulting engineers, J. G. Sylvester Associates, specializing in industrial radiography. An industrial X-ray laboratory, metallurgical laboratory, and physical testing facilities are located in Hingham, Mass.

Henry O. Fuchs has resigned as chief research engineer of Preco, Inc., Los Angeles, and will devote full time to applications and further developments of shot peening, flame hardening, and other activities of the Metal Improvement Co., Los Angeles. He has been a director of the company and chairman of its board since 1946, and is now vice-president. He will also remain connected with Preco on a consultant basis.

Thomas J. McCue has been appointed district manager of sales in the Philadelphia territory for Wyckoff Steel Co., Pittsburgh.

Norman Birch has been appointed vice-president in charge of operations of the Meadville, Pa., plant of the National Bearing Div. American Brake Shoe Co. A graduate of Massachusetts Institute of Technology, Mr. Birch joined the company in 1939 and has held various positions in the metallurgical department. In 1952, he was appointed general foundry superintendent, the position he held at the time of his promotion.

Robert A. Canning, formerly manager of production engineering, Carboloy Dept. of General Electric Co., has been named manager of quality control for both the Detroit and Edmore, Mich., plants. Mr. Canning, who joined Carboloy in 1946, holds a B.S. degree in electrochemical engineering from Massachusetts Institute of Technology.

Ralph R. Sorber has been appointed manager of the heat treat department in the Endicott, N.Y., plant of International Business Machines Corp. Mr. Sorber joined I.B.M. in 1950 as a heat treat operator, and in 1952 became an inspector. He later became a heat treat technician, and in 1953 joined the general manufacturing training program.

What's the Right X-ray Film?

PRODUCT:
Nozzle for jet plane's air conditioner.

MATERIAL:
Aluminum Alloy 355, ½ in. thick

EQUIPMENT:
140 k.v. x-ray machine

Kodak Industrial X-ray Film, Type A

FOURTEEN curved vanes are machined in the rim of this aluminum casting. It's foolhardy to "guess" if castings are sound and defect-free, machining costs are too great.

So, all rough castings go to the radiographer to be x-rayed. For these radiographs he uses 86 k.v. at a distance of 48 inches, 45 seconds exposure time. The film selected is Kodak Industrial X-ray Film, Type A.

This film gives him high contrast with little graininess. It's fine for examination of light alloys with short exposures at low voltages. Also has sufficient speed to use with high voltage equipment in radiographing thick or dense materials.

RADIOGRAPHY

. . . another important example of Photography at Work

THERE'S A RIGHT FILM FOR EVERY PROBLEM

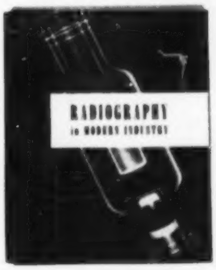
Whatever your radiographic problem, you'll find the best means of solving it in one of Kodak's four types of industrial x-ray film. This choice provides the means to check castings and welds efficiently, offers optimum results with varying alloys, thicknesses and radiographic sources.

Type A—has high contrast and fine graininess with adequate speed for study of light alloys at low voltage—heavy parts at intermediate and high voltages. Used direct or with lead-foil screens.

Type F—provides the highest available speed and contrast when exposed with calcium tungstate intensifying screens. Has wide latitude with either x-rays or gamma rays when exposed directly or with lead screens.

Type K—has medium contrast with high speed. Designed for gamma ray and x-ray work where highest possible speed is needed at available kilovoltage without use of calcium tungstate screens.

Type M—provides maximum radiographic sensitivity with direct exposure or lead-foil screens. It has extra-fine grain and, though speed is less than Type A, it is adequate for light alloys at average kilovoltages and for much million- and multi-million-volt work.



RADIOGRAPHY IN MODERN INDUSTRY

A wealth of invaluable data on radiographic principles, practice, and technics. Profusely illustrated with photographs, colorful drawings, diagrams, and charts. Get a copy from your local x-ray dealer—price, $3.

EASTMAN KODAK COMPANY
X-ray Division
Rochester 4, N. Y.

Kodak

Personals . . .

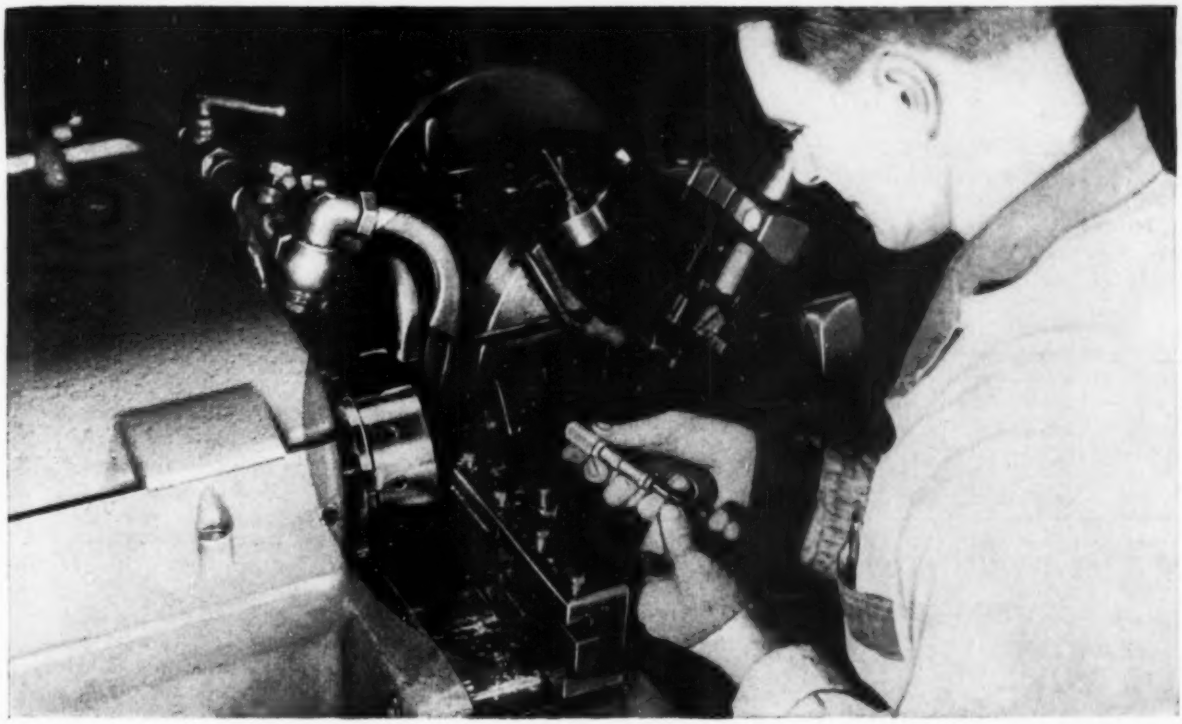
Morton C. Smith ⊕, who resigned last spring from the faculty of Colorado School of Mines where he was professor of metallurgical engineering, is now a staff member at Los Alamos Scientific Laboratory, Los Alamos, N.M. Mr. Smith spent the summer months completing his contracts as metallurgical consultant to NBS-AEC Cryogenic Engineering Laboratory, Boulder, Colo., and as a project engineer for Colorado School of Mines Research Foundation, Inc., Golden, Colo.

R. G. Matters ⊕ has been appointed assistant director of research at the Allis-Chalmers Mfg. Co., Milwaukee, Wis. Mr. Matters joined Allis-Chalmers in 1934 after receiving his chemical engineering degree from the University of Wisconsin. He was a metallurgist from 1935 to 1945, when he was named assistant superintendent of the chemical and metallurgical laboratories. In 1950 he was made a research supervisor.

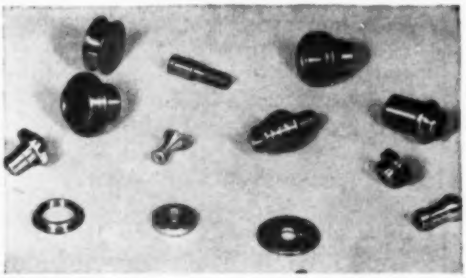
Byron B. Clow ⊕ heads the newly established branch office of Kaiser Aluminum & Chemical Sales, Inc., at Louisville, Ky., as branch manager. Mr. Clow is a graduate of the Montana School of Mines and prior to his present appointment was a technical sales consultant for Kaiser Aluminum in the Hawaiian Islands. He also served in the Los Angeles district and in Washington, D.C.

David W. Lillie ⊕, former chief of the metallurgy and materials branch of the U.S. Atomic Energy Commission's division of research in Washington, D.C., is now research associate in the metallurgy department of the General Electric Research Laboratory in Schenectady, N.Y. Mr. Lillie is a graduate of Harvard University who taught and studied at Massachusetts Institute of Technology before joining the A.E.C. in 1948. He was associated with the Crucible Steel Co. from 1939 to 1946.

J. F. B. Jackson ⊕ has resigned his position as director of the British Steel Castings Research Assoc., and is joining the board of A.P.V.-Paramount Ltd. of Crawley, Sussex, as deputy managing director.



TOOL LIFE INCREASED 40% USING CITIES SERVICE CUTTING OIL



ONE OIL FOR ALL? After poor results with many cutting oils, the Dunbar Machine & Tool Company discovered all their cutting jobs could be done to perfection using only one oil . . . Cities Service Chillo #44

NO EYE STRAIN. In addition to a 40% increase in tool life, owner Robert Dunbar found that the transparent characteristics of Chillo #44 help eliminate eye strain. Cutting operation is easily visible to operator.

Production Also Up, Reports Dunbar Machine & Tool Co.

THE PROBLEM . . . The Dunbar Machine & Tool Co., Massillon, Ohio, had a problem. It seemed impossible to find one oil which would perform economically and efficiently for ALL the jobs required of the firm's automatic screw machines.

THE SOLUTION . . . After trying many brands of cutting oil, "none of which gave good all-round performance," owner Robert Dunbar called in a Cities Service engineer. After careful analysis of the problem, the engineer recommended Chillo #44 cutting oil.

THE RESULTS . . . Using Chillo #44, the company observed these results: Tool life increased nearly 40% . . . Production increased accordingly . . . Additional savings realized due to chip draining characteristics of oil . . . Holding tolerances no longer any problem . . . Machine clean-up time now insignificant . . . Transparency of oil eliminates eye-strain . . . Less smoke and fumes at high speeds . . . Also excellent for lubricating purposes. Says Mr. Dunbar, "Our results with Chillo #44 permit us to heartily endorse this product."

If you have a cutting oil problem, consult your nearest Cities Service representative or write Cities Service Oil Company, Sixty Wall Tower, New York 5, N. Y.

CITIES SERVICE

QUALITY PETROLEUM PRODUCTS

Personals . . .

Richard A. Swalin is now a research associate in the metallurgy department of the General Electric Research Laboratory, Schenectady, N.Y. Dr. Swalin graduated from the University of Minnesota in 1951, and received his Ph.D. degree there earlier this year.

The establishment of four new sections and other changes in the development and research division of the International Nickel Co., Inc., have been announced by **Frank L. LaQue**, vice-president and manager of the division. **H. V. Beasley** has been placed in charge of the constructional alloy steels section; **Clarence H. Sample** is in charge of the newly established electroplating section; **V. N. Krivobok** heads the new stainless steel and heat resistant alloys section, and **T. E. Kihlgren** is in charge of the Inco nickel alloys development section. **Thomas P. May** has been appointed technical manager of the Kure Beach Corrosion Testing Station of the company near Wilmington, N.C., and **William H. Sparr, Jr.** has been appointed to succeed Mr. Beasley in charge of the technical field section in Pittsburgh.

Rinaldo A. Paci, after receiving a B.S. degree in metallurgical engineering from the University of Pennsylvania, is now a principal metallurgical engineer with the reactor metallurgy division of Battelle Memorial Institute, Columbus, Ohio.

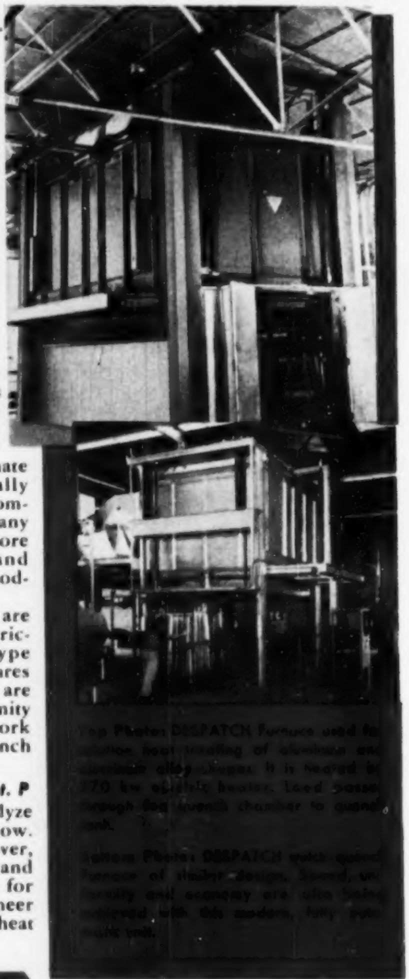
R. J. Cottingim is employed as purchasing agent and material director for Products Engineering Corp., Tulsa, Okla.

John E. Fries, Jr. has been appointed chief metallurgist for the National Bearing Div. of American Brake Shoe Co. Mr. Fries joined the company in 1949 after graduation from Massachusetts Institute of Technology. He will continue to be located at the division's Meadville, Pa., plant, where he was formerly plant metallurgist.

Robert E. Keith, who recently received the Ph.D. degree from the University of Michigan, has joined the staff of the General Electric Research Laboratory, Schenectady, N.Y. Dr. Keith is engaged in work with the alloy studies section of the metallurgy department.

Daniel J. Murphy, who returned from military service in Japan in May, has been assigned to the Los Alamos Scientific Laboratory as representative of the Armed Forces Special Weapons Project. At the Laboratory, Colonel Murphy has been designated as a staff member of the metallurgy research group. A graduate of West Point in 1935, he received his M.S. in engineering from Massachusetts Institute of Technology in 1939 and Ph.D. in metal physics from Columbia University in 1952. Prior to his duty in Japan, Colonel Murphy was head of the Pitman-Dunn Laboratories of Frankford Arsenal, where he coordinated many of the research programs concerned with the development of arms and ammunition for the Army Ordnance Corps, while being directly involved in the work of the laboratories' metallurgical staff.

James T. Ferguson, formerly section engineer in the works laboratory of General Electric Co., Erie, Pa., is now chemical unit engineer, materials and processes in the major appliance laboratory of the General Electric Co. at Louisville, Ky.



Improved Anodes for Acid Copper Plating*

One of the most annoying problems met by users of acid-copper electroplating baths, is the formation of anode sludge. The sludge consists of tiny metallic particles of copper which, in aggregate form, are carried by the electrolyte to the cathode surface, where some adhere and result in irregular growth and roughening of the deposit. If the electrolysis is continued long enough, as in electrotyping and electroforming, rough nodules form which cause much trouble.

The migration of these sludge particles to the cathode surface is controlled to some extent by enveloping the anode in a bag made of linen, fine canvas, or glass cloth, but the method is not entirely satisfactory. In addition to the time and expense involved, the bag interferes with circulation of the electrolyte, resulting in uneven corrosion of the anode and higher scrap losses.

Recently obtained data show that when an anode is prepared from copper containing a small amount of certain elements it becomes coated during electrolysis with an adherent surface film which stops the formation of metallic particles. A relatively thick cathode deposit may be obtained on such anodes without the growth of nodules, assuming, of course, that no solid particles of any other kind are permitted to enter the electrolyte. Effective films form when either phosphorus or arsenic in an amount greater than 0.005% is present.

Anodes of a number of commercial grades of copper and high-purity copper containing various added elements in controlled amounts were tested in plating baths with the following formula:

Copper sulphate ($CuSO_4 \cdot 5H_2O$)	28 oz. per gal.
Sulphuric acid	8 oz. per gal.
Chloride (30 ppm. hydrochloric acid)	trace
Glue	11 ppm.

The plating tests were made at (*Continued on p. 158*)

*Digest of "Effect of Anode Composition in Acid-Copper Plating", by R. P. Nevers, R. L. Hungerford and E. W. Palmer, a paper presented at the 41st Annual Convention of the American Electroplaters' Society, New York City, July 14, 1954.


if it has to do with
x-ray
it has to do with
PICKER
x-ray

Copper Plating . . .

(Continued from p. 156)
room temperature in glass battery jars containing 1.85 gal. of plating solution. Rolled-sheet copper cathodes were suspended by copper wire or strip. The electrodes were spaced 3 in. apart and varied in size from test to test, the face of the smallest being 3¼ x 1¼ in., the largest, 6 x 6 in. In most tests the anodes were not completely immersed and anode current density, based on the facing area, was usually maintained between 20 and 40 amp. per sq.ft. The electrolytes were agitated with air and deposition time ranged from 8 hr. to as much as one week of continuous plating.

In all tests involving high-purity anodes, such as cathode copper or electrolytic tough-pitch copper, a heavy coating consisting mainly of very fine copper particles soon adhered loosely to the anodes. The slightest movement of the anode detached aggregates of these particles, causing turbidity and forming layers of sediment.

Relatively impure commercial copper (fire-refined), on the other hand, becomes coated early in the plating run with a dark gelatinous film that is fairly adherent, although it does have a tendency to slide off as the anode is withdrawn. The coating begins to slough off during prolonged deposition and forms blackish wooly clumps that are easily broken and may be dispersed by vigorous agitation, as by aeration. Baths equipped with such copper anodes are virtually free from wandering, fine copper particles. Cathode deposits from such anodes are smoother than those from high-purity anodes and greater thicknesses of deposit are practical.

Development of an anode copper of reproducibly superior characteristics was attempted by adding to high-purity copper the optimum amount of elements found most desirable in film-forming characteristics. Extensive investigation revealed that wrought anodes of high-purity copper, to which a definite excess of phosphorus has been added, approach ideal behavior in acid copper plating solutions. Anodes containing 0.02 to 0.03% phosphorus become coated during plating with a thin,

(Continued on p. 160)


You can design light weight, longer life, and economy into your products by including N-A-X HIGH-TENSILE in your plans.
• It is 50% stronger than mild steel.
• It is considerably more resistant to corrosion.
• It has greater paint adhesion with less undercoat corrosion.
• It has high fatigue life with great toughness.
• It has greater resistance to abrasion or wear.
• It is readily and easily welded by any process.
• It polishes to a high lustre at minimum cost.
And with all these physical advantages over mild carbon steel—it can be cold formed as readily into the most difficult shaped stamping.
When you next start to redesign, get the facts on N-A-X HIGH-TENSILE. It's produced by Great Lakes Steel—specialists in flat-rolled steel products for over 25 years.
Make it WEIGH LESS... and LAST LONGER
with
N·A·X
HIGH-TENSILE STEEL
GREAT LAKES STEEL CORPORATION
N-A-X Alloy Division • Ecorse, Detroit 29, Michigan
NATIONAL STEEL CORPORATION

Copper Plating . . .

(Continued from p. 158)

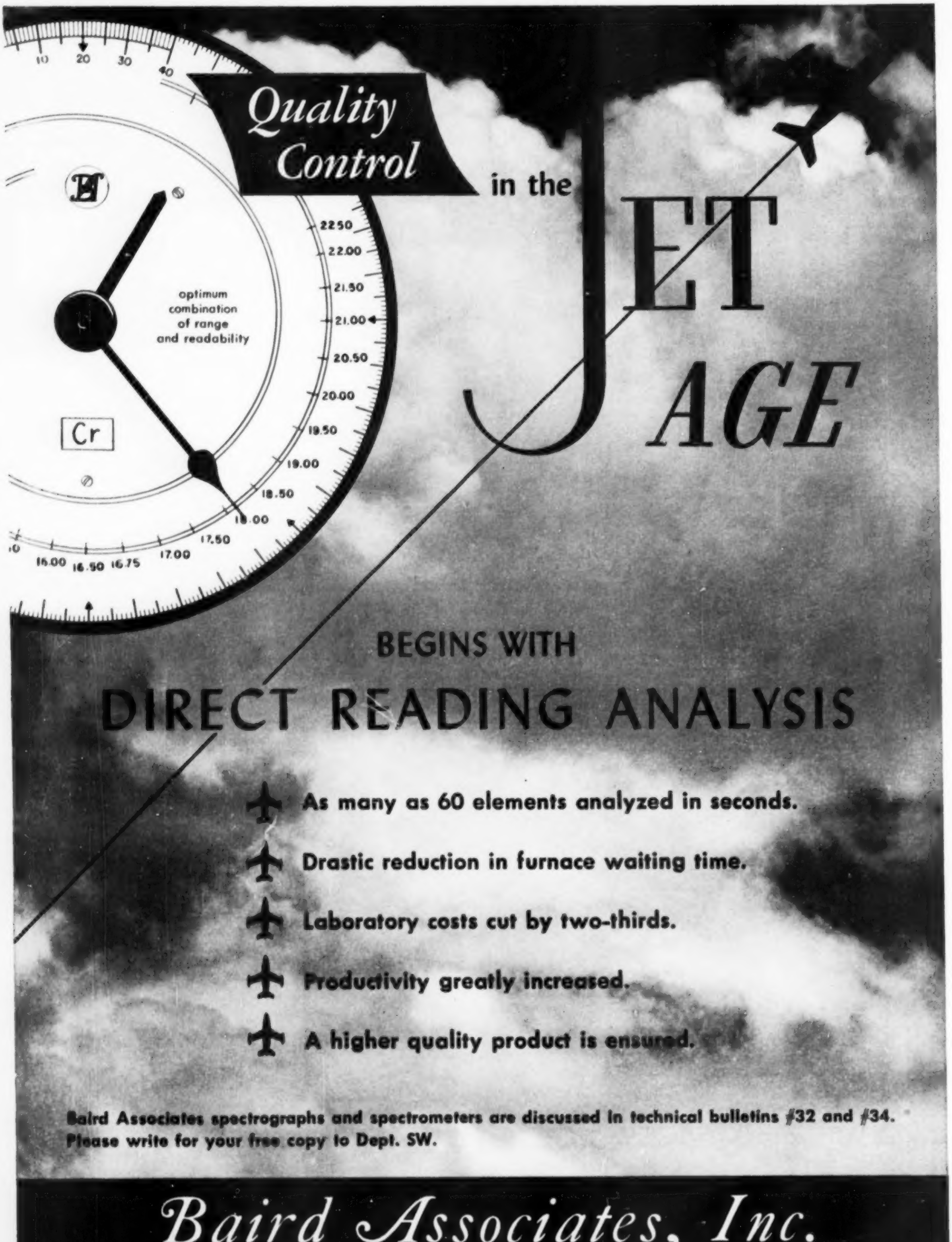
black film that adheres well, copper particles do not form, and the bath remains clear. The film is not disturbed when the anode is pulled from the bath and is so thin that anode cleaning is unnecessary. The film does not add resistance to the circuit and no additional voltage is required. Phosphorized copper anodes corrode uniformly and evenly, with much smoother surfaces than those of high-purity or fire-refined copper anodes.

The amount of phosphorus required is in excess of the amount necessary for deoxidation. Anodes containing less than 0.0005% phosphorus scarcely differed from electrolytic tough-pitch copper in sludge-forming properties, but a phosphorus-bearing copper anode containing as much as 0.04% phosphorus formed a good film free from any sludge. Still higher phosphorus contents may give equally good anode behavior but appear to offer no advantage – the heavier films formed may become detached and build up on the bottom of the tank.

Early experiments with phosphorized copper made of very high-purity copper showed that anode characteristics were slightly inferior to commercial coppers. Certain elements commonly present in other commercial coppers but absent in the very high-purity copper used as the alloy base were also important in determining anode behavior. The most important are silver, tellurium and selenium and the amounts involved are very small. A copper containing 0.0006% silver, 0.0008% tellurium and 0.025% phosphorus shows an improvement over the high-purity phosphorized material. A synthetic copper with 0.002% silver and 0.0014 tellurium closely reproduces the excellent behavior of commercial phosphorized copper of the same phosphorus content.

Copper anodes containing other deoxidants such as silicon, calcium, cerium and boron – in excess of amount required for deoxidation – sludged badly in use. The desirable anode characteristics are imparted by the phosphorus and are not associated with removal of oxides.

C. T. FINLEY


Quality Control
in the JET AGE
optimum combination of range and readability
Cr
BEGINS WITH
DIRECT READING ANALYSIS
As many as 60 elements analyzed in seconds.
Drastic reduction in furnace waiting time.
Laboratory costs cut by two-thirds.
Productivity greatly increased.
A higher quality product is ensured.
Baird Associates spectrographs and spectrometers are discussed in technical bulletins #32 and #34. Please write for your free copy to Dept. SW.
Baird Associates, Inc.
33 UNIVERSITY ROAD, CAMBRIDGE 38, MASSACHUSETTS, U.S.A.

Hard Coatings for Aluminum Alloys*

DURING the past few years at least three commercial processes for the production of very hard oxide films on aluminum and many of its alloys have made their appearance. These are the Martin Hard Coat, Alumite Hard Coating and the Hardas (Hard Aluminum Surfaces Ltd.) processes.

Each of these processes produces an anodic coating which is a porous film of aluminum oxide. The hard coating processes differ from ordinary commercial anodic coating treatments, which yield films having thicknesses in the range of 0.0001 to 0.0008 in., by producing coatings which are more dense and which range from 0.001 to 0.005 in. and greater in thickness. The main difference between normal anodizing and the hard coating processes is that the latter are performed at higher current densities and lower temperatures in a strongly agitated bath. In the Hardas process, both direct and alternating currents are used, whereas the Martin Hard Coat and Alumite Hard Coating processes require direct current.

This report is a study of the Martin Hard Coat process that was conducted by the Cornell Aeronautical Laboratory, Inc. The Wright Air Development Center sponsored this test program to investigate the effects of hard coatings on the properties of aluminum alloys and to obtain such data as would pertain to aircraft and other applications. Wrought alloys included in the investigation were 6061-T 6 (61 S-T 6), X 7178-T 6 (XA 78 S-T 6), 2024-T 4 (24 S-T 4), Alclad 2024-T 4 (24 S-T 4) and 7075-T 6 (75 S-T 6). Two casting alloys were tested, 356-T 6 and 220-T 4. Most of the coatings were from 0.0005 to 0.005 in. thick, with a few up to 0.009 in. The test program included evaluation of the characteristics of Martin Hard Coatings as well as their effect upon base-metal properties.

The increase in wear resistance is

(Continued on p. 164)

*Digest of "Study of Hard Coatings for Aluminum Alloys", WADC Technical Report 53-151, May 1953, and Supplement I, October 1953, by F. J. Gillig, Cornell Aeronautical Laboratory, Inc.

How Hot can a Jet Get?

Whoooosshh! Jet engines generate a powerful amount of heat . . . heat which, uncontrolled in flight, would cause disastrous metallurgical distortions within the delicately balanced engine. So the problem is . . . or rather *was* . . . how to provide a dependably accurate means of measuring exhaust temperatures so that the pilot might have control over how hot his jets get.

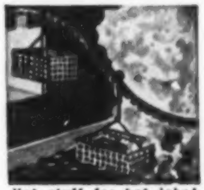
And the answer? Special wiring harnesses running from engine to instrument panel . . . harnesses now made exclusively with Hoskins Chromel-Alumel thermocouple alloys.

Yes, wherever durability and accuracy are required in a thermocouple . . . whether for jet engines or industrial furnaces . . . you'll find Chromel-Alumel *right* for the job. Extremely durable . . . highly resistant to heat, corrosion, oxidation . . . guaranteed to register true temperature-E.M.F. values within specified close limits.

That's only part of Hoskins' product picture, though. Other specialized quality-controlled alloys developed and produced by Hoskins include: Alloy 785 for brazing belts; Alloy 717 for facing engine valves; special alloys for spark plug electrodes; Alloy 502 for heat resistant mechanical applications. And, of course, there's Hoskins CHROMEL . . . the *original* nickel-chromium resistance alloy used as heating elements and cold resistors in countless different products.

Heating elements made of Hoskins Chromel deliver full-rated power throughout their long and useful life.

Sparks fly better, last longer in today's spark plugs . . . thanks to Hoskins' spark plug electrode alloys.



Hot stuff for hot jobs! Hoskins Alloy 502 is ideally suited to many mechanical-structural applications.

Chromel® NICKEL CHROMIUM WIRE

HOSKINS

MANUFACTURING COMPANY

4445 LAWTON AVENUE, DETROIT 2, MICHIGAN

Hard Coatings . . .

the most outstanding property conferred on aluminum alloys by the hard coatings. The resistance to abrasion of the hard coatings is far in excess of that of coatings produced by ordinary anodizing treatments and has been demonstrated to be equal to or better than that of thin cyanide coatings on steel. Using an Arlt abrasiometer, it was demonstrated that the abrasion resistance of hard coatings decreases with exposure to heat, humidity, and atmospheric conditions. The decrease is not proportional to time and, in general, the values for abrasion resistance after 11 months of exposure are only slightly below those for 6 months. Attempts to reduce the loss in abrasion resistance in a humid atmosphere were only moderately successful. Oil was found to have a detrimental effect on the abrasion resistance.

The most serious shortcoming of the coatings is their ability to drastically lower the fatigue strength of the coated alloy, these decreases being as much as 65%. The effect is not proportional to coating thickness, and coatings of 0.001 in. produce practically the same effect as 0.005-in. coatings. It is possible to mitigate somewhat the reduction in endurance strength caused by the coatings. A chromate sealing treatment resulted in a definite improvement in the fatigue strength of hard coated 75 S and 61 S alloys.

The average compression yield strength of the coating, as bonded to the base metal, appears to lie in the range of 50,000 to 60,000 psi., as compared to 10,000 to 15,000 psi. tensile yield strength.

The hard coatings increased the resistance to corrosion of all of the aluminum alloys tested. Exposure tests of up to 11 months were made in three different environments; a semi-industrial atmosphere, an atmosphere of relatively high humidity at 80 to 90° F., and a salt spray environment. Compared with regular anodic coatings and electroplated coatings, the hard oxide coatings showed superior resistance to salt spray.

The coatings on alloys 7075 (75 S) and X 7178 (XA 78 S) had the highest dielectric strength (3000 to 3500 v. for 0.005-in. coatings), and the films on alloys 356 and 220 had the lowest (1500 to 2000 v.).

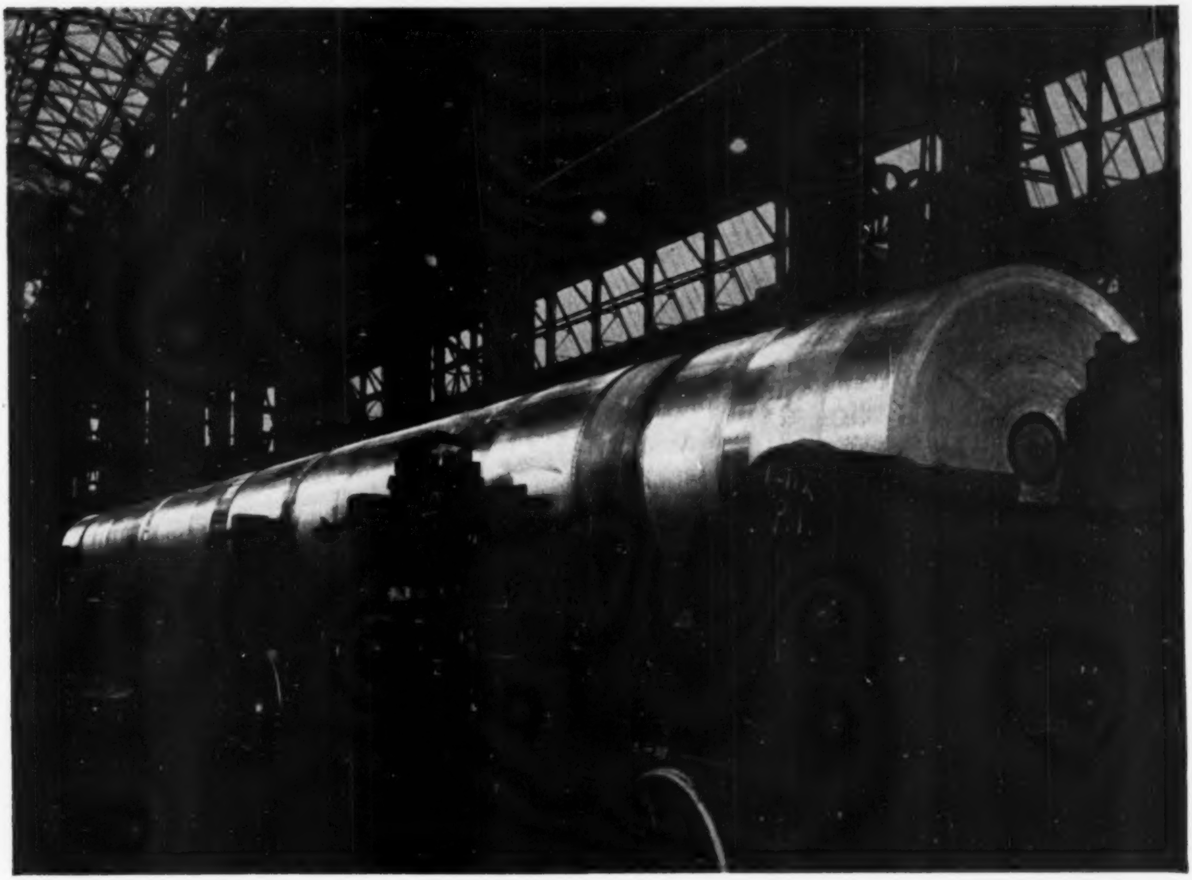
Certain deficiencies observed in the hard coatings were described. Crazing or fine hairline cracks occur in the coatings owing to the differential thermal expansion of the metal and the coating. Blisters were encountered in some of the hard coated Alclad 2024 (24 S) specimens when the coating thickness exceeded that of the cladding. The coatings tend to crack and crumble at sharp corners owing to the difference in specific volumes of the coating and the metal from which it is formed.

Because extensive examination of the hard coatings by X-ray diffraction methods failed to reveal any crystalline structure, it is believed that they are amorphous in structure and therefore very similar to ordinary anodic coatings.

It was concluded that alloy 2024 (24 S) is not suited to the hard coating process used.

A considerable amount of other data was obtained on the hard coated alloys, including their linear expansion coefficients, resistance to erosion, resistance to thermal shock, thermal conductivities of the coated alloys, throwing power of the electrolyte, and color of the coatings.

W. C. Cochran



Formation of Metallic Compounds of Iron*

During the course of previous work on solid solutions of iron it became evident that the formation of metallic compounds was also determined by the positions of the component metals in the periodic table and by their relative sizes. The present paper is a more detailed exposition of these ideas.

Many continuous solid solutions of similar metals (in systems such as iron-nickel, iron-chromium and others) are stable only at high temperatures. During slow cooling they undergo a solid-state transformation to form metallic compounds, named Kurnakov compounds in honor of the discoverer. Analysis of experimental data on the formation of metallic compounds from solid solutions or directly during solidification of the alloy led to several important conclusions.

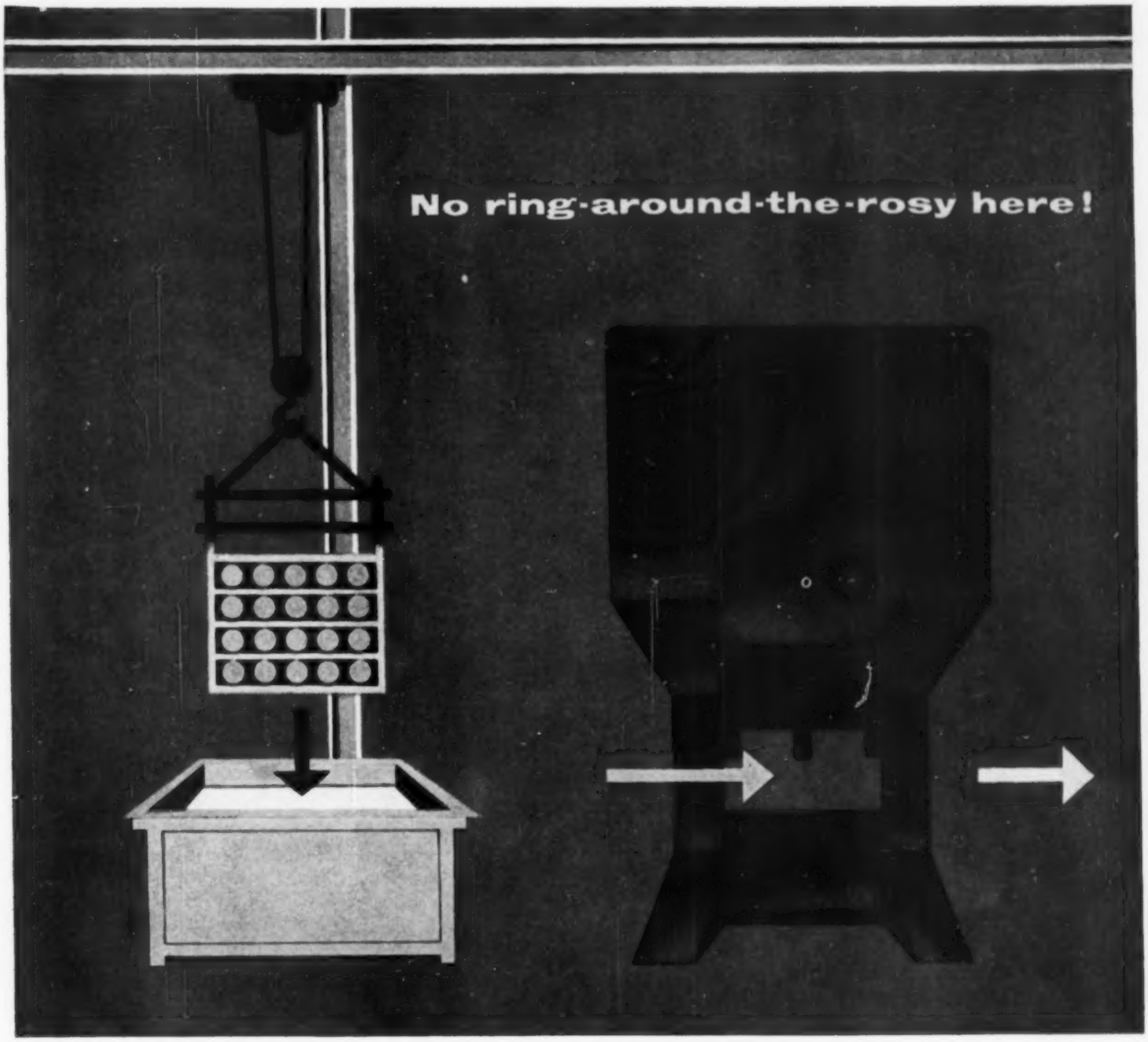
First, the temperature of formation of Kurnakov compounds of iron depends on the similarity of the reacting metals to iron, as determined by their positions in the periodic table. Both for metals in the same group and for those in the same row, the temperature of formation increases with increasing difference in atomic diameters (corresponding to increasing separation from iron in the periodic table).

Second, on attaining the limiting value of difference in atomic diameters (greater than 8 or 9%), the metallic compounds form directly during crystallization. The temperature of formation of these compounds also depends on the positions of the elements in the periodic table and on the differences in atomic diameters. Experimental data on binary compounds of iron with elements of the fifth, sixth, and eighth groups, and of the fourth, sixth, and eighth rows showed the following regularities:

1. The difference in atomic diameter between iron and elements of the fifth group is greater than with the sixth and eighth groups. In each group this difference increases with

(*Continued on p. 168*)

*Digest of "Several Regularities in the Formation of Metallic Compounds of Iron", by I. I. Kornilov, *Doklady Akademii Nauk SSSR*, Vol. 91, 1953, p. 261 to 263.



With the new Pennsalt Fos Process, cold steel can be extruded into finished shapes . . . directly . . . with important economies in manufacturing. Cold steel discs or billets are formed into shafts, cylinders, tubes, gear blanks and many other parts in the press. This eliminates up to 80% of all machining . . . creates a direct line manufacturing system that lowers costs and improves production.

The Pennsalt Fos Process is now being used in automotive, tube, wire drawing and ordnance plants. The process includes a new Pennsalt lubricant and a proven method of locking that lubricant to the steel. The Fos Process insures the smooth and rapid flow of cold steel through the die, even at extreme pressures.

Practically all the original metal can be utilized with Pennsalt cold extrusion techniques . . . work cycles can be reduced . . . and over-all production speeded up. Superior physicals can be obtained from carbon steels, along with a better, smoother finish. Multiple draws without interim recoating and annealing, and greater reductions per draw are now practical.

Is Fos Process practical for your plant . . . your products? Send us details of desired application, or blueprints of products. We will be glad to evaluate possibilities. Customer Service Department, 523 Widener Building, Philadelphia 7, Pa.

Pennsalt Chemicals

THE PENNSYLVANIA SALT MANUFACTURING COMPANY

Iron Compounds . . .

increase in atomic number of the element.

2. The temperature of formation of compounds during crystallization increases with increase in the separation of the element from iron, both by group and by row.

3. Kurnakov compounds are formed up to the critical difference in atomic diameter.

4. A similar regularity of temperature of formation holds for these compounds.

5. On the basis of thermochemical principles, it can be considered that the heat of formation of a metallic compound is greater the higher its melting temperature.

7. The stability of a metallic compound is greater the higher its melting point.

A. G. Guy

Conducting Primer for Resistance Welding*

Protecting the inner surfaces of welds from corrosion is a problem which fabricators of spot welded steel assemblies usually meet in one of four ways: (*a*) by coating the region of the welds with an electrically conducting primer before welding, (*b*) by welding through wet or soft coats of conventional primers, (*c*) removing paint in the region of the weld from previously coated parts, or (*d*) dipping the completely assembled structure. Use of conducting primers appears to be the most favored method, but most such primers now available are heavily loaded with zinc dust to provide conductivity, often resulting in a poor coating bond. This does not make for a good base upon which to apply subsequent finishing.

A search for alternative primer pigments included brass, zinc, stainless steel, soft iron, nickel, copper and carbon black powders incorporated into a plasticized nitrocellulose binder in such proportions that the

(*Continued on p. 170*)

*Digest of "A New Type of Primer for Resistance Welding", by A. J. Elleman and N. D. P. Smith, paper No. 21, Fourth International Conference on Electrodeposition and Metal Finishing, London, April 23, 1954. (*Transactions* of the Institute of Metal Finishing, 1954).

Resistance Welding . . .

binder just filled the voids of the powder. This insured that particle-to-particle contact could be expected in the dried films. Of all compositions studied, those containing ferromagnetic materials, soft iron and nickel, were far and away the lowest in electrical resistance, and nickel was appreciably lower than iron powder.

Photomicrographic examination of the various films showed the ferromagnetic particles to lie in more or less continuous chains, while the other nonmagnetic powders were in small, discrete groups. Development of these "chains" could be increased by magnetization of the nickel powders in the wet vehicle.

Since a high rate of settling made the nickel powder somewhat impractical for commercial application in a primer, studies were extended to several different types of nickel, nickel-iron and soft iron powders having a smaller particle size. An 80-20 Ni-Fe alloy was found to have zero remanence and when examined microscopically showed no chain formation, whereas all the other samples gave chains, although the type of chain formation varied with the method of preparation in carbonyl-nickel powders. It was found, for example, that a grade of nickel made by the carbonyl process, having an apparent powder density of 1.42, gave much finer chains than one with density of 2.82.

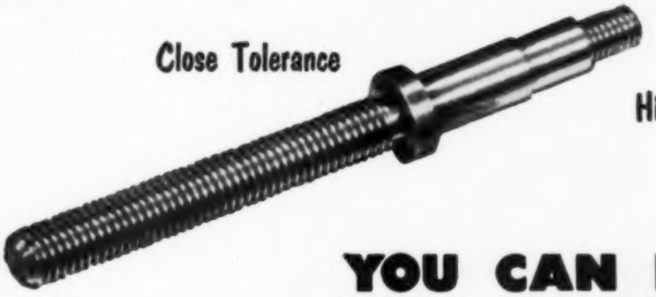
On the basis of test results and supply considerations, a grade B nickel powder was chosen for subsequent experiments on the strength of welds made in coated panels. Compositions were prepared in which three degrees of grinding and three volume concentrations of nickel powder were used. They ranged from 30 to 40% powder by weight, the balance resin and thinner. Electrical resistance was found to decrease with time of grinding and with increase in powder volume. Increased grinding time also led to improved settling properties, the settlement at the longer grinding times being soft and easily incorporated into the vehicle.

Three different vehicles – bituminous, oleoresinous and alkyd – were pigmented with the nickel powder and test films were prepared in three thicknesses. Then welds were made at three different currents and three welding pressures. Finally, the strengths of the resulting welds were checked for each set of variables.

Conclusions drawn from these extensive tests indicated that adequate electrical conductivity for welding can be obtained without overloading the composition with conducting nickel filler. In common with most paints containing metallic fillers, the setlement rate is rather high, particularly if dip-tank operation is involved. This difficulty might be minimized by careful formulation of the primer and possibly by the development of more suitable grades of nickel dust.

Greatest disadvantage to the use of nickel-dust primer is the high cost of the nickel and its relatively tight supply situation. While nickel supply is becoming somewhat easier, the cost factor remains, and could restrict the primer to applications where other considerations outweigh high cost. A. H. ALLEN

Close Tolerance



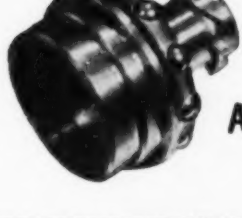
High Strength

YOU CAN HAVE ALL SIX ... PLUS Uniform Machinability

Fine Surface

Toughness

Hardenability



Accuracy of Section

Maybe you want some of these properties in your steel parts. Or a combination of them. Or only one.

No matter which ones you need, you get them—plus *uniform machinability*—in Republic Cold Drawn Steels.

That's why so many manufacturers have come to Republic with their machining problems. Manufacturers whose costs and production records show their automatics aren't turning out what they could.

Republic's 3-D Metallurgical Service focuses the combined experience of the Field, Mill and Laboratory on your particular problem. And the recommendation you get is based on your plant, your product, and your equipment.

There's no reason to deny yourself this service. It costs only the price of a phone call to your nearest Republic office. And it can save you a lot. Do it today.

REPUBLIC STEEL CORPORATION
Alloy Steel Division • Massillon, Ohio
GENERAL OFFICES • CLEVELAND 1, OHIO
Export Department: Chrysler Building, New York 17, N.Y.

REPUBLIC COLD DRAWN ALLOY STEEL BARS

REPUBLIC STEEL

Other Republic Products include Carbon and Stainless Steels—Sheets, Strip, Bars, Wire, Pig Iron, Steel and Plastic Pipe, Bolts and Nuts, Tubing


COPPER ★ BRASS
1801
REVERE
ALUMINUM
REVERE


ALUMINUM
Revere knows its
ABC's
in sheet metals
The news is good for those companies which have followed the profitable course of making more and better products out of aluminum. For it is good to know that a full line of aluminum sheet products is available from a company such as Revere with its high reputation for producing quality metals.
The first copper sheet rolled in America came from Paul Revere's original mill. Brass mill products have been a Revere specialty for well over a century. With this unequalled background, and with the most advanced aluminum rolling equipment and techniques, Revere offers you aluminum coiled and flat sheet, circles and blanks in a wide range of gauges and widths and in the five most widely used alloys. You can be sure that Revere knows its A-B-C's in metals—"A" for Aluminum, "B" for Brass, "C" for Copper. Why not call Revere NOW?
Other Revere aluminum products include tube, extruded products, electrical bar, forgings, rolled shapes and eyelet products. Revere Copper and Brass Incorporated, Founded by Paul Revere in 1801, Executive Offices: 230 Park Avenue, New York 17, N. Y.

Mechanical Properties of Weldable Vanadium Steels*

THIS REPORT extends the knowledge of the experimental steels in which vanadium is substituted for molybdenum. (See also *Metal Progress*, September 1954 issue, p. 200.) In this work, the properties and structures were studied after normalizing and tempering. Three 14-lb. ingots were cast from 20-lb. induction melts of six compositions based on steels A and B in the earlier report, the difference in the analysis being in the substitution of 0.15 and 0.10% V for the 0.20 and 0.25% Mo, or in partial replacement with 0.10% V.

Two ingots from each set of three were forged to ⅝-in. thick plate, and the third to 1¼-in. diameter bar; these were normalized at 1650° F. and tempered at 1200° F. for 1 hr. As in the earlier work on steels that were normalized only, the vanadium addition resulted in an increase in proof stress. For example, the 0.2% proof stress of a 0.15% C, 0.78 Mn, 0.09 Si, 0.73 Ni, 0.92 Cr, 0.14 V (2A in report—same composition as steel 56 in previous report) was 75,300 psi. as compared to the base steel A – 0.14% C, 0.89 Mn, 0.18 Si, 0.56 Ni, 0.93 Cr, 0.22 Mo, which had 69,900 psi.

The microstructure of the vanadium steels showed some tempered martensite (or lower bainite) which was not present in samples studied in the earlier work. This condition, when considered in comparison with the improvement in proof stress of the original steels A and B after comparable heat treatment probably explains why the increase in proof stress was not so spectacular.

The conclusions are that in a normalized and tempered weldable steel of Type A, the molybdenum can be replaced by a smaller amount of vanadium (about 0.14%) with no loss in proof stress. Also that in the same condition, in steel of Type B, the molybdenum could be replaced by the same amount of vanadium with no loss in proof stress. In both types, there was no evidence of temper brittleness in the vanadium steels when air cooled from the tempering temperature.

REVIEWER'S COMMENT – The project is very interesting and follows along lines quite similar to those being investigated by some in this country at the present time. They are finding that rather excellent yield properties can be obtained in low-carbon alloy steels by normalizing and tempering, and that such steels will have good weldability provided the chemical elements which promote the formation of martensite or acicular bainite are minimized. This seems to be the explanation for the improvement shown on notch toughness, as well as yield ratio of the steels wherein vanadium replaced molybdenum. And we concur that this change in properties results from a change in microstructure. Based on our knowledge, the British would get corresponding good properties with still lower contents of vanadium than they have worked with. It is encouraging to notice that they are beginning to subscribe to the American belief that properties of steels are controlled by the type of microstructure as well as composition.

P. R. WRAY

*Digest of "Vanadium-Bearing High-Tensile Weldable Steels", *Welding Research*, Vol. 7, October 1953, p. 103-107.

IMPACT FORGING
FROM
HIGH STRENGTH ALUMINUM ALLOYS

These Impact Forgings are shown three-fourths actual size

These aluminum thick bottom cans were formerly machined from bar stock at great cost—now impact forged by Hunter Douglas to final print in one fast operation at low cost. The parts are illustrative of the endless variations in part geometry possible with Hunter Douglas cold impact forging. The "no-draft" characteristic effectively eliminates machining. Simply trim to length, drill holes in base for attaching bolts and the part is ready for final assembly.

To the economies achieved through impact forging can be added the superior physical properties resulting from this mass production technique perfected by Hunter Douglas. Increased fatigue properties are obtained and bending stresses at the inside corners are redistributed parallel to the flow lines rather than cross grain as would be the case if the part were machined from bar stock.

If you have a design problem that requires a similar part for mass production in quantities up to a million or more a month, remember the name, Hunter Douglas.

Our Research and Development Engineers welcome the opportunity to consult with you.

IMPACT FORGING • STRENGTH OF FORGING • TOLERANCE OF EXTRUSION • H D

write for free literature on your company letterhead **HUNTER DOUGLAS** ***CORPORATION***

DEPT. MP-11 • RIVERSIDE, CALIFORNIA • TELEPHONE RIVERSIDE 7091

Controlled Atmospheres for Sintering . . .

(Continued from p. 123)

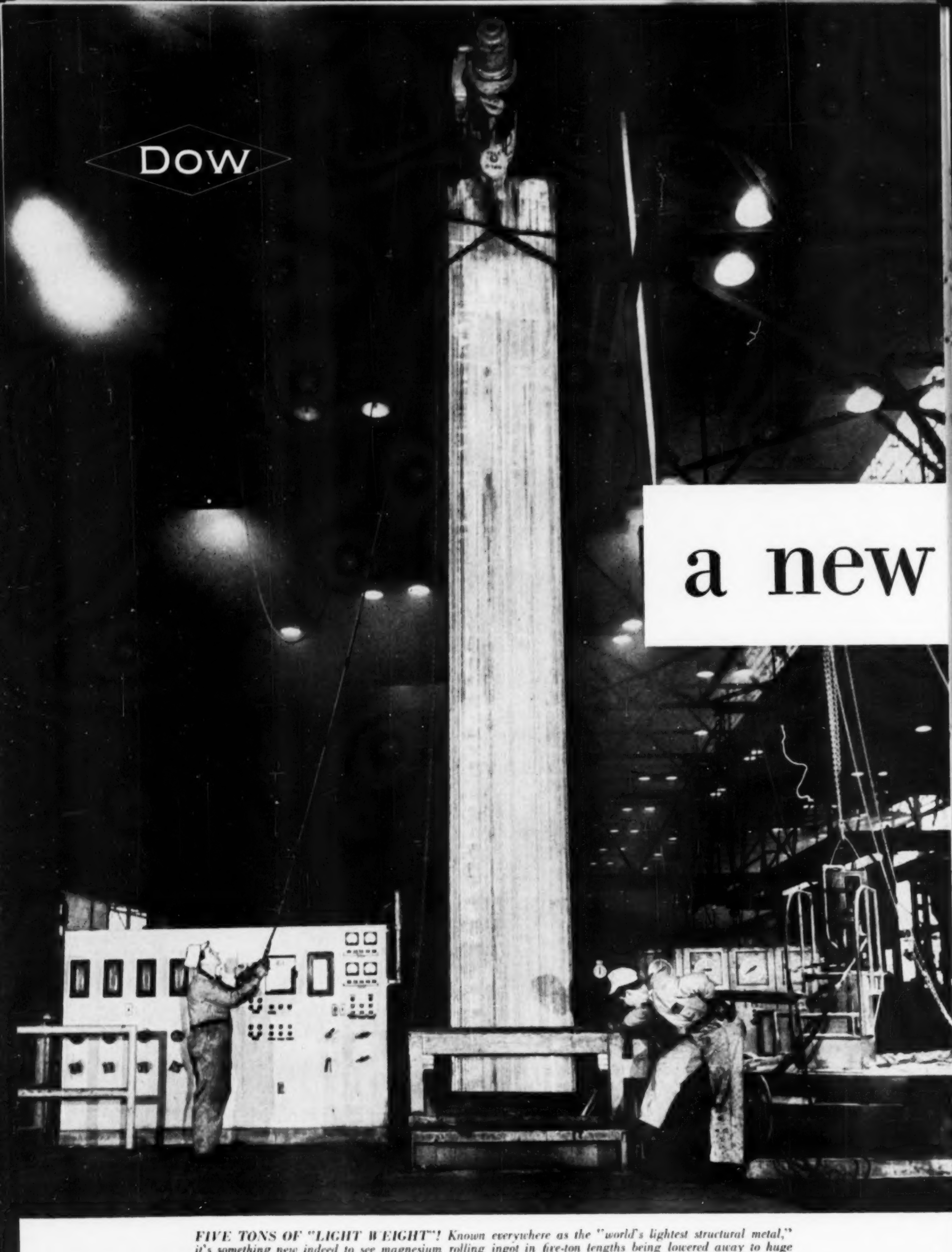
2250° F., the long soaking periods (1 to 2 hr.) make it necessary to use ceramic trays to avoid carburizing and fusing the compacts.

Pusher-type furnaces are used for these high-temperature sintering operations. Heating elements have to be of the refractory type and if muffles are used, they also have to be of the refractory type. In general, production furnaces for sintering brass, bronze and iron compacts at temperatures to 2050° F. are of the mesh-belt conveyer type. From the standpoint of cost, an open construction is suitable, provided that a properly constructed preheat section permits burning off the volatiles, and the atmosphere is of sufficient volume to insure a flushing action out the front. Alloy muffles are preferred where purity of atmosphere is a prime factor.

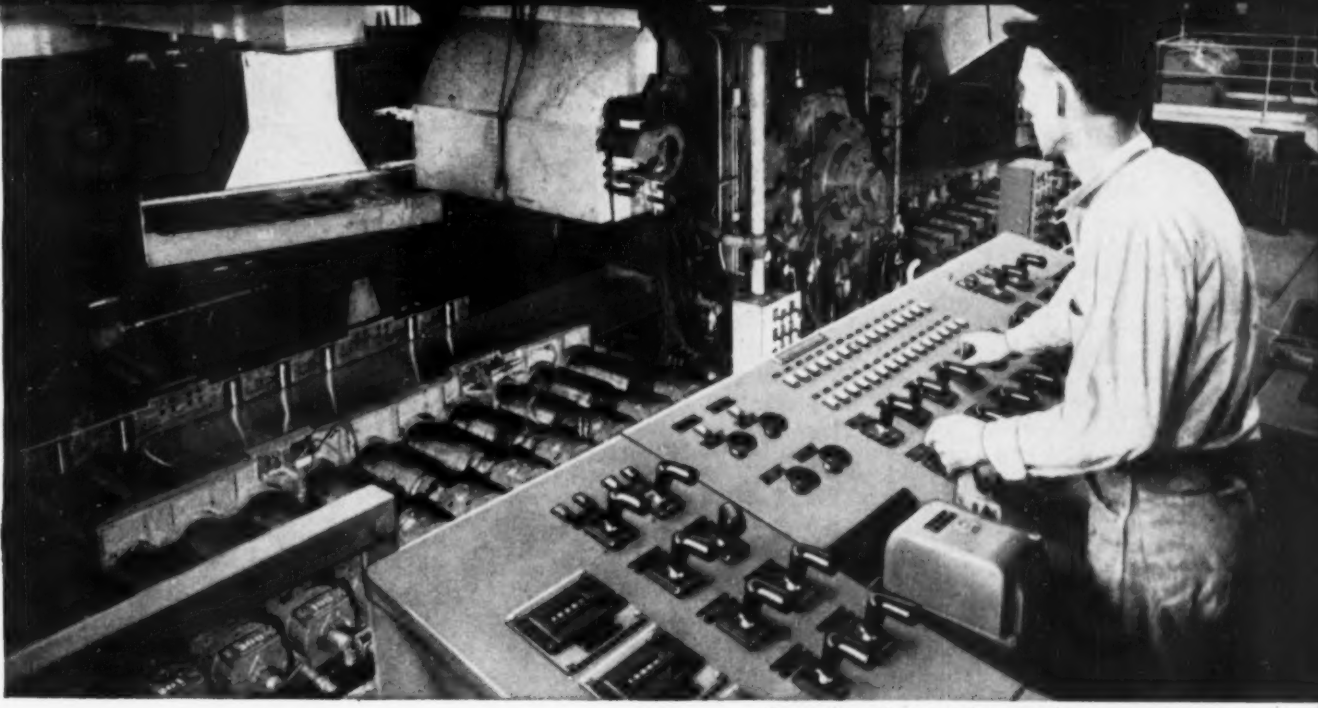
Not as much work has been done on stainless steel sintering as may be expected in the near future. The atmospheres and furnaces used for brass, bronze or iron powders are not always adequate for the sintering of stainless steel. Stainless steel will not stay clean in the usual atmospheres. The best commercial atmospheres for keeping stainless steel clean, and for reducing existing oxides, are pure dry hydrogen and dissociated ammonia. These atmospheres will not stay pure and dry in the normal furnaces. Contamination from the brickwork or from any oxidized muffle or belt will nullify any possible chance of keeping the surface of the steel bright. Production furnaces for stainless steel must be constructed with metal muffles and should be kept clean. Also, in order to be commercially practical they must be constructed to permit normal openings without undue consumption of atmosphere.

By utilizing the principle of the elevated heating section with inclined hoods, it is possible to construct a production furnace which is commercially practical from the standpoint of accommodating work loads and also in regard to economy of operation. With a metal muffle extending through the entire furnace, such a furnace protects the atmosphere from contamination, and the stainless steel compacts will stay perfectly bright. At 2100° F., which is the limit temperature for belts and muffles, the stainless steel compacts will sinter together if they are in contact with each other.

It is encouraging, however, that as temperatures are increased, the ability to keep stainless steel bright is made easier. This permits the use of some types of refractory muffles for sintering. Ordinarily, refractory muffles of any type are not satisfactory for conventional heat treatment of the ordinary stainless steels. As temperatures are increased to the 3000° F. needed for sintering tungsten carbides, special furnaces are involved with high-temperature muffles, molybdenum wound, and pure dry hydrogen atmosphere. However, since this is a special field it will not be considered here.



FIVE TONS OF "LIGHT WEIGHT"! Known everywhere as the "world's lightest structural metal," it's something new indeed to see magnesium rolling ingot in five-ton lengths being lowered away to huge saws in rooms beneath the earth—where shorter ingots can be prepared for rolling in Dow's new coil mill.

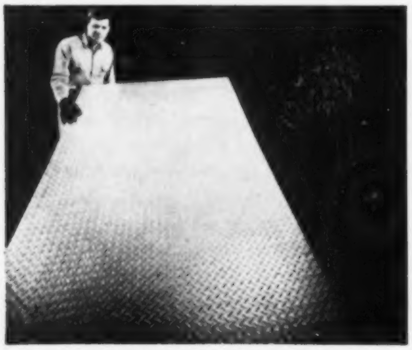


Operator's touch controls slab movement through 84" rolls.

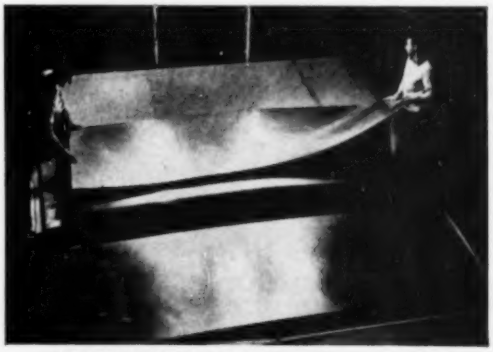
look at Magnesium!

UP TO 25% PRICE REDUCTION ON PLATE & SHEET

Now Available! Tremendous new Dow facilities, now in operation, are geared to supply large quantities of magnesium plate, sheet and extrusions—in many new sizes, shapes and forms. Years of experience with magnesium were combined with newest *volume production techniques* to create the world's first 84-inch coil mill for rolling magnesium. If you are a designer, engineer or manufacturer—anxious to cut costs and improve products—it's time to take a *new look* at strong, lightweight magnesium! Call the nearest Dow office or write today for information—THE DOW CHEMICAL COMPANY, Magnesium Sales Department, Midland, Michigan.



MAGNESIUM PLATE—Light, strong magnesium tread plate—lengths to 16 feet, widths to 6 feet, thickness to 2 inches.



MAGNESIUM SHEET — New production facilities and rigid inspection insure top quality magnesium products.

MAGNESIUM COIL—Note size of coil, illustrates new availability in greater widths and lengths.

you can depend on DOW MAGNESIUM

DOW

Strain-Aging of Mild Steel Strip*

This latest contribution on this subject is of interest because results are given for all commercial types of steel used for rolling strip. In addition, aging tests after 3 years of exposure at normal temperature are reported; rimmed, killed and steels of varying nitrogen were studied.

In this investigation one specimen of "pure" iron was compared to two basic openhearth rimming steels, low-nitrogen bessemer steel, basic bessemer rimming steel (high nitrogen), openhearth rimming steel (vanadium-treated with 0.028% V), and aluminum-killed basic openhearth and basic bessemer. Complete analyses are given in the report.

Steel	C	N	Al
Pure iron	0.002	0.001	0.003
Basic openhearth, rimmed	0.05	0.005	0.005
Basic openhearth, rimmed	0.05	0.006	0.005
Bessemer, rimmed (Al)[1]	0.04	0.010	0.005
Basic bessemer, rimmed	0.05	0.015	0.005
Basic openhearth, rimmed[2]	0.07	0.005	0.005
Basic openhearth (Al killed)	0.08	0.004	0.080
Ugiperval[3]	0.05	0.013	0.075

[1]Special low-nitrogen steel.
[2]0.028% V.
[3]Aluminum-killed bessemer.

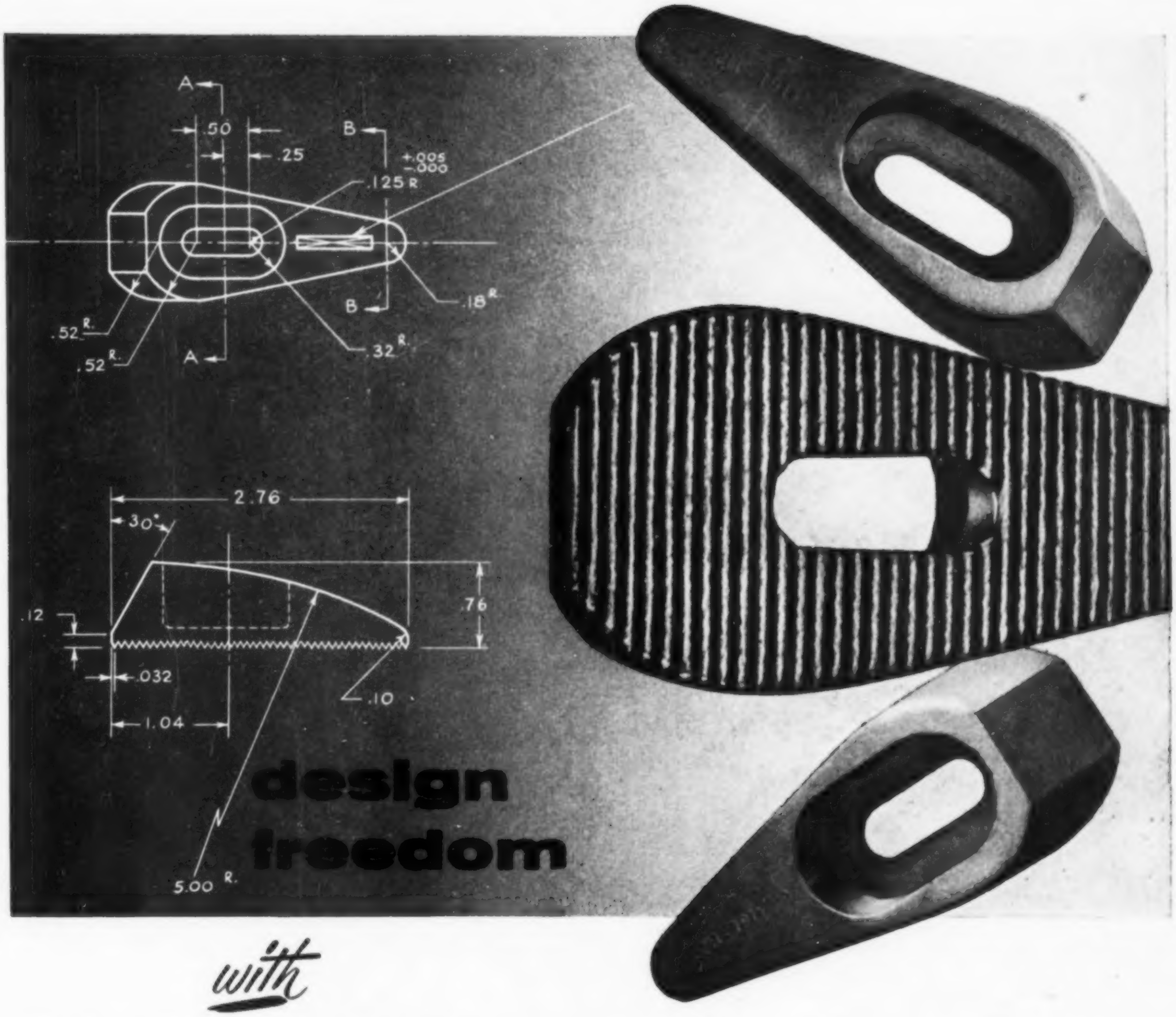
Test specimens were prepared by hot rolling slabs of the different steels, pickling and then cold rolling (60% reduction) into strips on a tandem mill. The cold rolled steel was slit through the center to obtain a strip 1 in. wide, and from this were cut the 6-in. lengths for physical tests and aging treatments. These pieces were bright annealed at 1290° F. and then temper rolled on a four-high mill to 1½ to 3% reduction. The pure iron sample was annealed in vacuum to avoid surface contamination. This amount of rolling removed the yield point on tensile testing. The samples for tensile tests were standard British strip specimens machined before annealing and temper rolling. Tensile and Vickers hardness tests were made on all samples immediately after rolling and after aging at room temperature for 2 hr., 1 day, 4 days, 1 week, 2 weeks, 1 month, 3 months, 6 months, 1 year, 2 years, 3 years. Complete tabulations of the hundreds of tests made are given in the paper.

Room-temperature aging occurred in both the openhearth and bessemer rimmed steels but did not appear in either of the killed steels or in the vanadium-treated rimmed steel, even after 3 years. Aging was detected by the appearance of an actual yield point in the stress-strain curve, and by an increase in hardness and decrease in elongation. The two rimmed bessemer steels age hardened in four days after temper rolling and the rimmed openhearth steel after 2 weeks.

The same test series were then heated to 210° F. for 24 hr., 390° F. for 3 hr., and 480° F. for 1 hr. and again tested. The intensity of aging

(Continued on p. 182)

*Digest of "Strain-Aging of Mild Steel Strip", by B. Jones and R. A. Owen-Barnett, *Journal* of the Iron and Steel Institute, Vol. 177, June 1954, p. 209-219.



with

CRUCIBLE ACCUMET PRECISION INVESTMENT CASTINGS...

Here's another good example of how Accumet Precision Investment Castings help put an end to design problems.

To machine the curved and tapered surfaces, elongated hole and counterbore, and serrations on this AISI 4140 alloy steel aircraft part, would have been too costly to be practical. But the parts were quickly and economically produced by investment casting.

More and more parts are being *designed* specifically for the investment casting process. And there are good reasons why. Crucible Accumet Precision Castings allow the greatest freedom of design. Intricately shaped parts can be made of any grade of steel, including high-alloys, in large quantities and at low cost.

It will pay you to let your local Crucible representative give you the whole story of how Accumet Precision Castings can help you produce a better product at lower cost.

Join your Civil Defense Team NOW!

CRUCIBLE first name in special purpose steels

54 *years of* *Fine* *steelmaking* **ACCUMET PRECISION CASTINGS**

CRUCIBLE STEEL COMPANY OF AMERICA, GENERAL SALES OFFICES, OLIVER BUILDING, PITTSBURGH, PA.

REX HIGH SPEED • TOOL • REZISTAL STAINLESS • ALLOY • MAX-EL • SPECIAL PURPOSE STEELS

Strain-Aging . . .

was greater after reheating to these temperatures for both the openhearth rimmed steels and the two rimmed bessemer steels than after 3 years at room temperature. The rimmed bessemer steels did not show as great a difference as the rimmed openhearth steel.

The two aluminum-killed steels showed no aging effects at 210° F., but at 390 and 480° F. the yield stress and hardness increased slightly. Only a small yield point was noted at these temperatures and the authors concluded that the artificial aging of the aluminum-killed steels at these temperatures could not be compared with that obtained from natural aging of the rimmed steels at room temperature. The vanadium-treated rimmed openhearth steel showed no return of yield point at 210, 390 and 480° F. but did have high yield stress and lower ductility after treatment at 480° F.

Additional tests were made on three of the steels after aging at 120° and 165° F. (50 and 75° C.). The extent of aging was greater than that observed at room temperature and less than in the samples heated to the higher temperatures.

The aging of low-carbon rimming and killed steels of openhearth and bessemer origin has been investigated for periods up to 3 years after temper rolling. Results show that the yield stress of openhearth steel gradually attains the value of the original annealed steel when fully aged at room temperature, but in bessemer steel it attains a higher value. The yield stress and hardness increase slightly in the aluminum-killed steels after aging at room temperature, but the steels remain comparatively stable, with no return of the yield point.

The physical properties of the fully aged rimming steels have been compared with those obtained by accelerated or artificial aging treatments at temperatures of 210 to 480° F. In the latter tests, high values of yield stress, yield ratio, and yield-point elongation were obtained. The differences between natural and artificial aging are smaller in bessemer steel than in openhearth steel, owing to its greater rate of aging at room temperature. The results obtained have been discussed, with particular reference to the influence of residual stresses.

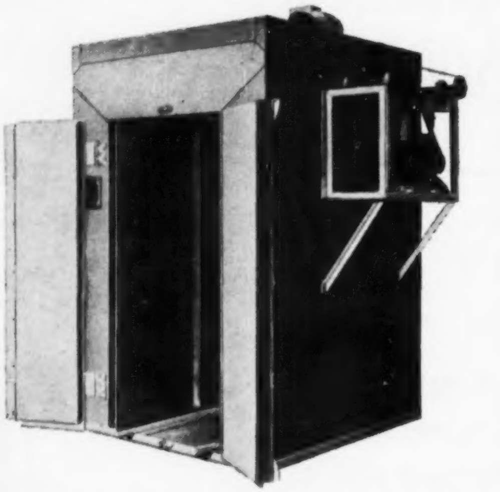
Artificial aging treatments of aluminum-killed steels have very different effects from natural aging; in these steels there is a return of the yield point after treatments at 390 and 480° F. Also, the yield stress and yield ratio of these are higher than those of the fully aged steels.

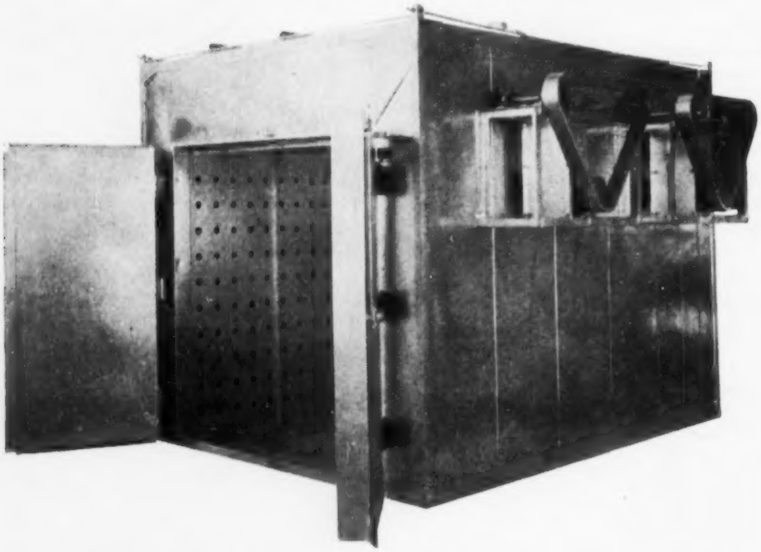
There was no return of the yield point in the vanadium-treated rimming steel after artificial aging, but a small yield point reappeared in pure iron on temper rolling and aging at 210, 390 and 480° F.

The best results for the steels aged at the three higher temperatures, as compared with natural aging, were at 210° F., the differences being accentuated at higher temperatures.

Artificial aging at 120 and 165° F.

(Continued on p. 184)





Strain-Aging . . .

gives more comparable results with natural aging, the speed of which can be followed by heating for various times at these temperatures.

The effect of cold storage of a basic openhearth, a basic bessemer, and an aluminum-killed steel after temper rolling has been investigated for periods of up to 6 months, and the results have been compared with aging at room temperature. There was a marked retardation in the rate of aging in the rimming steels, the properties being particularly stabilized at 4° F. for several months. The aluminum-killed steel was further stabilized by cold storage.

E. C. Wright

Special Technique Used to Obtain Melting Point of Ti*

The determination of the melting point of titanium has been difficult because of its high reactivity with all refractories and most gases. Consequently, the standard method of determining the melting points of most metals, which is to hold a relatively large mass of the pure metal at the melting point for a sufficiently long period to permit a number of observations, cannot be employed. Previous investigations have disclosed melting points that range from 1700 to 1795° C. (3090 to 3265° F.). Undoubtedly, many of the results reported have been affected by impurities in the titanium metal and also by its reaction with the container or atmosphere in which the tests were conducted.

The furnace used in these experiments was essentially a spiral of tungsten wire enclosed in a series of molybdenum radiation screens. The furnace assembly was covered with a cylindrical water-cooled brass hood that fitted into an O-ring in the water-cooled furnace base. Water-cooled wires for the current and a vacuum line were brought through

(Continued on p. 186)

*Digest of "The Melting Point of Titanium", by T. H. Schofield and A. E. Bacon, *Journal* of the Institute of Metals, Vol. 82, December 1953, p. 167-169.

Profitable Features for You:

- *Sturdy Construction Throughout*
- *Easy, Rapid Die Changes*
- *Fully Automatic Control*
- *Dependable Pumping Equipment*
- *Complete Auxiliary Machinery*
- *Shearing Deflection Eliminated*
- *Low Cost Maintenance*
- *Efficient Economical Operation*

Get Extra Dividends in Advanced Design Features... *backed by 70 years of heavy machinery "know how"*

The designing skill of our extrusion engineers (who have grown up with the industry) has eliminated handicaps found in conventional presses. In addition, our reputation for precision building, in the heavy machinery field, assures you of dependability in extrusion presses and auxiliary equipment. Consult us whether your need is for a single unit or a complete extrusion plant.

The Youngstown Foundry & Machine Co.

SERVING INDUSTRY SINCE 1885

Youngstown, Ohio

Melting Point . . .

the furnace base. The vacuum developed at room temperature is from 1 to 5×10^{-4} mm. of mercury.

An alumina tube, one end of which rested on the furnace base, was inserted inside the radiation shield and heating coil. The tube supported a molybdenum platform upon which was placed a zirconia crucible 1 in. long and ½ in. diameter.

The titanium metal specimen was a cylinder 0.656 in. long and 0.250 in. diameter, in the bottom of which a hole 0.031 in. deep and 0.094 in. diameter, was bored so that only a ring of metal 0.031 in. wide was in contact with the crucible. The temperature observations were made with an optical pyrometer that was sighted through a glass window in the top of the furnace cover and with the pyrometer filament focused on the base of an axial hole drilled in the top of the metal specimen. The optical pyrometer was calibrated against a standard tungsten strip lamp at temperatures of 2190 to 3630° F. before and after the observations. No change in calibration was found. In order to check the reliability of the technique described, the melting points of similarly prepared metal samples of iron, nickel, and platinum were determined since the true melting points of these metals are well known.

In the tests the furnace was first evacuated and then sufficient argon (99.8% pure) was introduced to give a slight pressure of about 4 mm. of mercury. The argon prevented film formation on the cover glass above the furnace and was particularly necessary in the case of iron, but not required when nickel or titanium was charged. The furnace was heated from room temperature to near the melting point in about ½ hr. When a temperature about 390° F. below the expected melting point was reached, optical temperature measurements were begun, continuing until melting occurred.

At the melting point, liquid metal began to rise in the sighting hole of the sample and simultaneously an apparent temperature drop was observed due to departure from black body conditions.

The melting points of iron, nickel and platinum, which are known accurately, were checked within 2

to 3° C. of the accepted melting point of these metals. This established the validity of the measuring procedure used in this investigation. Two different specimens of the purest iodide titanium were studied; one gave a mean melting temperature of 3010° F. and the other 3020° F. E. C. WRIGHT

The Control of Mechanical Properties in Austempering*

THIS ARTICLE deals with the effect of transformation time and the degree of completion of the transformation on the mechanical properties of steel upon austempering. For the benefit of the uninitiated reader, the author begins with a brief history and description of isothermal transformation and the invention of austempering. The article should prove to be profitable reading to anyone interested in these topics from a practical or theoretical standpoint.

Ordinary heat treatment was essentially an art developed through a century of experience, and prior to 1930 metallurgists regarded the cooling rate as the sole determinant of the structure developed during the quenching of steel. Davenport and Bain realized that the temperature of transformation rather than the cooling rate determined the structure that would form and on this basis initiated the isothermal method of studying the decomposition of austenite. They held the view that in ordinary heat treating, the temperature of transformation merely is selected by the cooling rate. (This view is an over-simplification. Krainer and Kroneis, and others, have shown that the cooling rate affects such important facts as nucleation and that, for example, pearlite transformation on continuous cooling at certain rates can occur at lower temperatures than on isothermal transformation.) Time, the other important variable, determines the completeness of the reaction.

Isothermal transformation has

***Digest of "Factors Affecting the Isothermal Transformation of Austenite in the Intermediate Range (Bainite Range)", by Otto Schaaber, *Draht* (English Edition), No. 19, February 1954, p. 19-25.**

taught us more about austenite transformation than have any of the other methods of investigation. The technique is to quench small specimens (which have been heated to the "austenitizing temperature") in a constant-temperature bath, withdraw the specimens (one at a time, after different holding periods) and immediately quench them in water. Thus, untransformed austenite is converted to martensite whereas structures resulting from transformation at the holding temperature remain unaffected. The "incubation period" or time required for transformation to start, and the "transformation time" required for over 99% of the austenite to transform, can be determined microscopically for a series of isothermal transformation temperatures below A_1. Plotting the incubation and transformation times along the x-axis on a logarithmic scale and temperature along the y-axis on a linear scale, produces the well-known TTT or isothermal transformation diagram.

Prior to 1930, ferrite, pearlite and martensite were the only transformation structures which were well known and understood. In 1930, Davenport and Bain in the United States (and Wever and Engel in Germany) discovered a new transformation structure which was formed isothermally in a temperature range between those where pearlite and martensite formed. In 1931, United States Steel Corp. applied for a patent on the isothermal transformation of steel in that temperature range, between 1100 and 300° F. This method became known as austempering.

The essential feature of austempering is that it produces neither pearlite nor martensite, but a structure which later has become known as bainite in the U.S. and the "intermediate structure" in Germany. Wever and Engel, as well as Davenport and Bain, showed that this structure has favorable properties without being tempered. Later, Payson and Hodapp showed that the superiority of austempered bainite is restricted to a hardness range of Rockwell C-30 to 45. The reports of others failed to confirm the superiority of bainite formed through

(Continued on p. 192)

Metals Engineering at Gulf Oil

As discussed by Dr. B. B. Wescott, *Executive Vice-President, Gulf Research & Development Company,* and Mr. L. W. Vollmer, *Director, Materials and Production Chemistry Division*

"Gulf is an important user of metals for drilling, production, transportation and refining equipment. That's the biggest part of our metals engineering work here, advising on the selection of the metals best suited for each job.

"In sales, we must study metals used by our petroleum products customers. To produce cutting fluids and oils for quenching, tempering, rolling, forming and hot

Inspecting the results of continuous metal cutting fluid tests at Gulf's research center are: C. N. Bowers, Materials Section Head, Materials & Production Chemistry Division; B. B. Wescott, Executive Vice-President, Gulf Research & Development Company; F. F. Versaw, Shop Superintendent, Engineering Division; and L. W. Vollmer, Director, Materials & Production Chemistry Division . . . all members of the American Society for Metals and readers of *Metal Progress*.

forging, we must understand the problems involved.

"Auto makers, in designing higher compression engines, continually create new problems involving fuels and lubricants. Oil companies collaborate with the auto makers to find the best solutions, which may require a new alloy, a different treatment for metal parts, a modified fuel or lubricant, or even a combination of these improvements.

"Because metals are of such major importance in all of our own operations and in the use of our products by our customers, many of our men are Metals Engineers—the readers of *Metal Progress.* We depend on them in making many product and purchase decisions and in promoting full and effective utilization of our products."

Austempering . . .

austempering. The reasons for these discrepancies lay in the incomplete knowledge of the factors which influence the results of austempering. Experiences gained from conventional heat treating do not apply to austempering.

The author states that metallurgical literature of about 1942 created the impression that the yield strength of austempered steel was low. He cites austempering data for four steels which support the view that especially the 0.01% yield point, also commonly referred to as the elastic limit, but also the 0.2% yield strength, the notched bar impact toughness and the fatigue strength are *improved* as the bainite transformation proceeds to completion. (The original U.S. patent on austempering mentioned the importance of letting the transformation proceed to completion.) Results are reported on two nickel-chromium steels (VCN 45 – 0.30 C, 4.36 Ni, 1.17 Cr – and VCN 35 – 0.23 C, 3.63 Ni, 0.81 Cr), one manganese spring steel (0.51 C, 1.2 Mn, 0.18 Ni, 0.18 Cr) and one manganese-vanadium steel (42 Mn V7 – 0.41 C, 1.63 Mn, 0.22 V). The austempering temperatures were 473 and 563° F. for VCN 45 and VCN 35 respectively, 645° F. for the manganese spring steel, and 527° F. for 42 Mn V7. The hardness was about Brinell 400 for the manganese spring steel and VCN 35, Brinell 430 to 440 for VCN 45, and Brinell 510 to 530 for 42 Mn V7.

The amount of bainite in the tested material varied between 62 and 100%, times to completion between 20 and 1600 min. (about 27 hr.). Even differences as small as those between 95 and 99.5% bainite created large differences in the 0.01% offset yield. An increase from 91 to 99% bainite in steel 42 Mn V7 resulted in 100% increase of the elastic limit. The most remarkable such increase, from 53,400 psi. at 78% transformation (or bainite) to 171,400 psi. at 99% transformation, or about 320%, was noted for steel 42 Mn V7; the minimum increase, from 92,800 psi. at 87% transformation to 127,000 psi. at 100% transformation, gave only about 37% improvement in elastic limit, this for steel VCN 45.

The improvements in elastic limit

(Continued on p. 194)

Austempering . . .

were usually accompanied by a decrease in ultimate strength, amounting to not more than 13% and by an increase in 0.2% yield strength varying between 3 and 35%. The elongation in a 10-diameter gage length and the reduction of area were usually unaffected, except in steel 42 Mn V7, for which elongation in 10 diameters increased from 1.4 to 4.4% and reduction of area from 2% to 50%. Impact data were given only for the manganese spring steel, which showed an average Charpy impact toughness of 168 ft-lb. per sq. in. after 3 min. transformation at 645° F. and 246 ft-lb. per sq. in. after 40 min., or a 46% increase.

The author expected also to find an increase in fatigue strength to accompany the increase in elastic limit (0.01% yield). Although his investigation was terminated by the destruction of his fatigue machine, sufficient data had been obtained on the manganese spring steel to permit tentative conclusions to be drawn. Twelve data had been obtained on specimens transformed 3½ min. at 626° F. and on oil quenched and tempered specimens. All of them fell on the same S-N or Wohler curve, whereas data obtained on seven specimens transformed 30 min. at 626° F. fell on a higher Wohler curve. It seemed quite indisputable, even in spite of the paucity of the data, that the fatigue limit of the former was about 76,000 psi. and that of the latter in the vicinity of 85,000 psi.

Methods of determining the progress of transformation have been investigated and evaluated by the author. Hardness tests were unreliable while several other methods, including mechanical testing and electrical or magnetic measurements, were too complicated. Dilatometric measurements were preferred.

A rugged and accurate dilatometer has been perfected recently by the author after ten years of experimentation. Its axis is inclined to the vertical, and specimens of various sizes and shapes (including small manufactured parts or pieces which have been sawed or even broken from a bar) can be positioned for measurement quickly and accurately

(Continued on p. 196)

Austempering . . .

in a specially designed measuring device which transmits length changes to a dial gage graduated in 0.00004-in. divisions over a range of 0.040 in.

The analysis of the results was facilitated by special graph paper with an autocatalytic ordinate scale that resembled a probability scale (described by J. B. Austin and R. L. Rickett, *Transactions*, American Institute of Mining and Metallurgical Engineers, Technical Publication No. 964, 1938) and a logarithmic abscissa-axis. By plotting the extent of completion of the reaction (that is, percentage of bainite) along the y-axis and time along the x-axis, a straight line was obtained – just as a cumulative probability curve, plotted on probability paper, will result in a straight line. This device enabled the reaction time to be determined accurately.

C. A. Liedholm

Mechanism of Fatigue Failure*

The commonly held hypothesis concerning what happens to metal during alternate stressing of such intensity that "fatigue failure" will result is that the repeated plastic movements (slip) inside the crystal progressively work harden the metal in certain microscopically small regions until the ductility or plasticity is "exhausted" – whatever that word may mean. (An alternative hypothesis is that the increased atomic mobility during alternating slip enables various small lattice vacancies to migrate and accumulate into relatively large voids or embryonic cracks.)

The authors have examined the "work hardening" postulate by studying seven single-phase metals and alloys. Small specimens 0.2 in. diameter were fatigued axially by alternating compression and tension, thus damaging the metal throughout its entire cross section, and at

(Continued on p. 198)

***Digest of "Softening of Certain Cold Worked Metals Under the Action of Fatigue Loads", by N. H. Polakowski and A. Palchoudhuri. American Society for Testing Materials, 1954 Preprint No. 74, 12 p.**


Try SANDVIK Coromant
CARBIDE TOOLS DESIGNED FOR LONGER-LASTING TOOL "BITE"
Coromant's quality and high wear-resistance means lower maintenance cost—higher production per tool.
The reasons for SANDVIK COROMANT'S success are:
1 EXTENSIVE RESEARCH COMBINED WITH ENGINEERING SKILL
Sandvik's modern metallurgical laboratories have developed carbides extremely well suited in hardness, wear and cratering resistance and strength for every type of material.
2 BASIC PURITY OF RAW MATERIAL
The ore from Sandvik's tungsten mine is among the purest found anywhere in the world.
3 UNIFIED CONTROL BY SANDVIK FROM ORE TO FINISHED PRODUCT
From the tungsten mine through each production stage, Sandvik maintains close control and careful inspection.
4 HIGH QUALITY, SHOCK AND VIBRATION RESISTANT STEEL SHANKS
5 UNIQUE BRAZING METHOD WITH HIGH MELTING POINT BRAZING
6 COMPETENT ENGINEERING SERVICE
Thousands of work files are at your disposal along with well trained field engineers to help to solve your machining problems.
Coromant is available:
• In a wide variety of tools and blanks from stock—including many shapes and designs which have been considered "specials" before.
• In all standard grades with improved performance to suit a wide range of applications.
• Grades permanently color-identified on the end of tool shank and etched in the carbide blanks.
• In the new, time saving "Coromant Combination Cutter."
Why not try Coromant's long-lived "bite" on your application. Contact Sandvik for further information.
COROMANT DIVISION • SANDVIK STEEL, INC.
111 Eighth Avenue, New York 11, N. Y. • WAtkins 9-7180
Detroit: 20005 James Couzens Hwy, Detroit 35, Mich. • VE 7-9507
Cleveland: 1736 Columbus Rd., Cleveland 13, Ohio, CHerry 1-2303
SANDVIK CANADIAN LTD. • P. O. Drawer 430, Station O, Montreal 9, P.Q. • BYwater 7501 • 25 Milford Avenue Substation 83, Toronto, Ontario • CHerry 1-3477
From ore to finished product within the same company
SANDVIK Coromant
SS-90

Fatigue . . .

such a rate that the temperature never was raised above 90° F. The central active portion of these pieces, 0.75 in. long, was then tested in compression and for hardness.

All specimens originally in the annealed condition *increased* in compressive stiffness and strength after cyclic strain. All corresponding specimens originally cold drawn some 30 to 40% *decreased* in compressive strength and hardness after cyclic strain, the amount of loss being proportional to the amplitude of the alternating stresses and the number of cycles.

The authors emphasize that their results are for single-phase metallic structures which are incapable of strain hardening by precipitation or by phase transformation. For the type of metallic structure they investigated, however, the facts are not consistent with the "cold working" hypothesis of fatigue. Rather they indicate that single-phase metals in both soft (annealed) and cold worked conditions gradually approach a specific limiting condition. The annealed metal is work *hardened* up to that level. The cold drawn metal, originally above the limiting condition, is *softened* by cyclic plastic flow down to the limiting conditions. E. E. T.

Denseners Improve Casting Quality

Considerable gain has been made during the past 20 years in the production of ferrous and nonferrous castings of enhanced properties, structural soundness and density. These improvements have resulted from advances in metallurgy and foundry practices—the former in respect to compositions and control of structures in the cast metals, and the latter in the techniques of gating, feeding and temperature control of the melts. Despite these advances the problem of nonuniform solidification of metal in castings having sections of different thicknesses still persists. It is for this reason that increasing attention is being paid to methods of inducing a progressive order of solidification.

(Continued on p. 200)

Denseners . . .

As is well known, the speed of solidification and the cooling rate of cast metals have strong influence on their general properties. The solidification rate is the more important of the two, because it is during freezing that cavities and porosity are formed if the liquid shrinkage is not effectively compensated for. The size, shape and orientation of the crystal structure are determined during this stage of the process.

A discussion of these factors is most opportune, and it appears in an English book, "Densening and Chilling in Foundry Work", written by Edward Longden and published by Charles Griffin & Co. of London. In it the author describes in useful detail the application of "denseners" (people in the United States would probably call them "densifiers"—they are really heat absorbers) and the associated function of suitably placed feeder heads. Metallic denseners have been employed for a long time to promote directional freezing and soundness of certain ferrous and nonferrous castings, but little information has been published on the materials available and how these materials can be used. This book is a source for such information. Its author, an outstanding personage in British foundry circles and president of the Institute of British Foundrymen, has had every opportunity to put into practice the methods advised in this book.

The book deals primarily with cast iron, then steel, and to a very limited extent with nonferrous castings. Nevertheless, the general principles involved are basically the same for ferrous and nonferrous alloys. A large number of the examples referred to are large castings—19 tons for a guntube boring bar, a 10-ton slag ladle, 20-ton chilled rolls, and a heavy "leading nut" casting in bronze. Complete details are given with accompanying drawings for the various types of denseners. The heat conductivity of mold materials is also discussed. Detailed methods are supplied relating to the casting of a variety of products, from chilled rolls and car wheels to gear blanks and grooved pulleys. Undoubtedly, this book will fill an important place in the foundry literature.

H. J. Roast

Low-Alloy Ferritic Steels Checked for Turbine Wheel Service*

RELATIONSHIPS between temperature and stress as a function of service life for four low-alloy ferritic steels in the form of commercial forged and heat treated turbine wheels for turbojet engines are clarified by data on tensile, rupture and total deformation properties at 1000, 1100 and 1200° F. The four steels examined in this investigation are SAE 4340, "17-22 A"S (0.3 C, 1.25 Cr, 0.4 Mo, 0.60 Si, 0.25% V), H-40 (0.3 C, 3 Cr, 0.5 Mo, 0.5 W, 0.8% V), and C-422 (0.2 C, 13 Cr, 1 Mo, 0.8 W, 0.25% V).

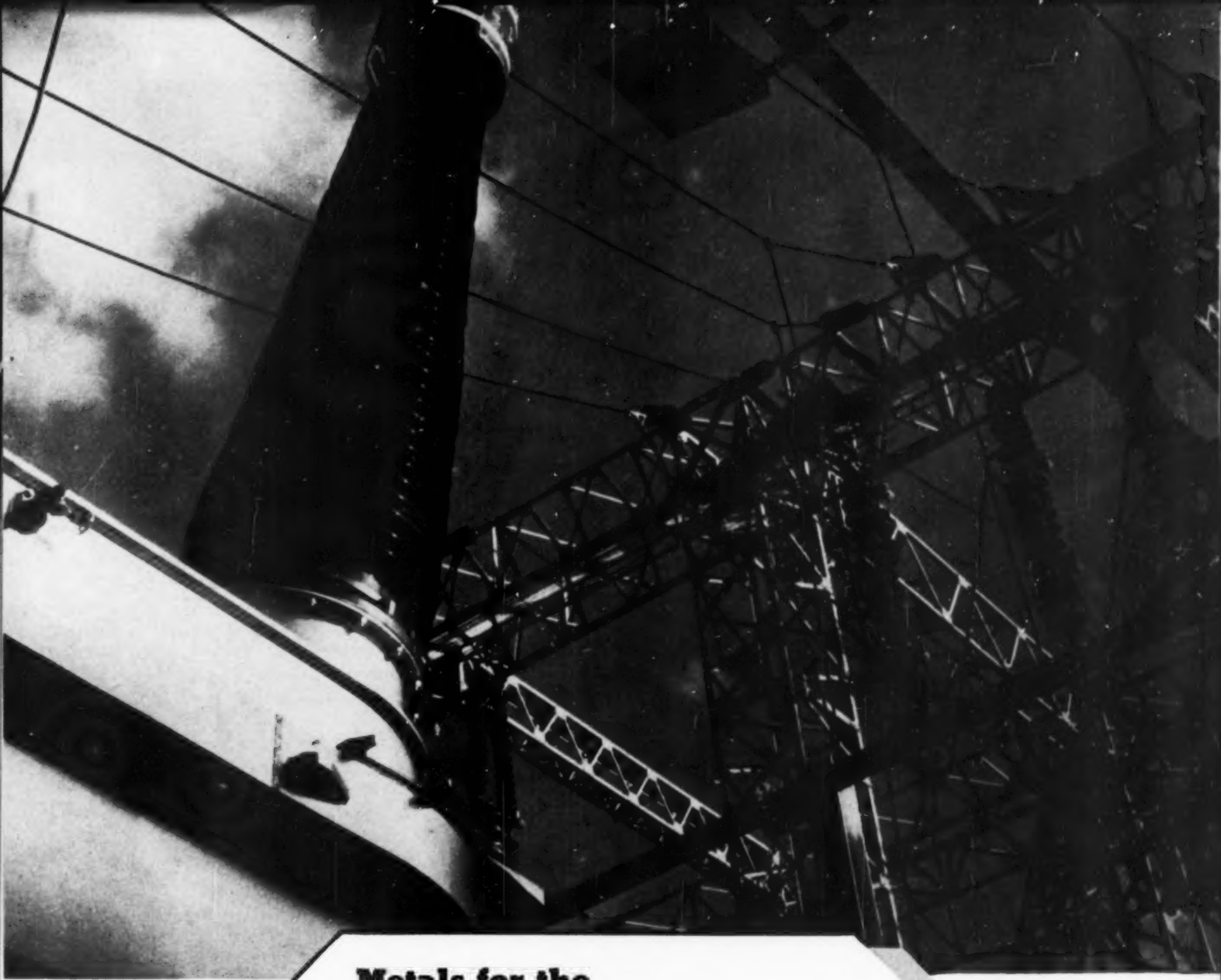
Influence of heat treatment first was surveyed by rupture tests at 1100° F. on normalized and tempered, oil quenched and tempered, and interrupted quench and tempered wheels at 19½ in. in diameter, 4⅝ in. thick in the hub area and 3⅜ in. thick at the periphery. The wheel of each alloy appearing to have the best properties was used to obtain tensile, rupture, total deformation and creep data at the three elevated temperatures.

Low-alloy hardenable ferritic steels would have two significant advantages in turbine wheel service. First, they require relatively small percentages of scarce or strategic elements; second, their production and fabrication characteristics are superior to those of the high-alloy austenitic steels commonly used in jet turbine wheels.

Temperatures of heat treatment were those established by the suppliers of the alloys, while tempering conditions after hardening were selected to yield a hardness range of Brinnell 280 to 320, this being representative of the hardness usually required to provide adequate strength at the wheel centers for meeting the high stresses at low temperatures encountered there.

(Continued on p. 204)

*Digest of "High-Temperature Properties of Four Low-Alloy Steels for Jet-Engine Turbine Wheels", by Arthur Zonder, Adron I. Rush and James W. Freeman; WADC Technical Report 53-277, Part I, prepared for the Materials Laboratory of the Wright Air Development Center, Air Research and Development Command, USAF, Wright-Patterson Air Force Base, Ohio, Nov. 1953, 66 p.



Turbine Wheels . . .

Test specimens or slices were cut from different locations in the wheels, in both surface and central planes, and both radial and tangential at the rims.

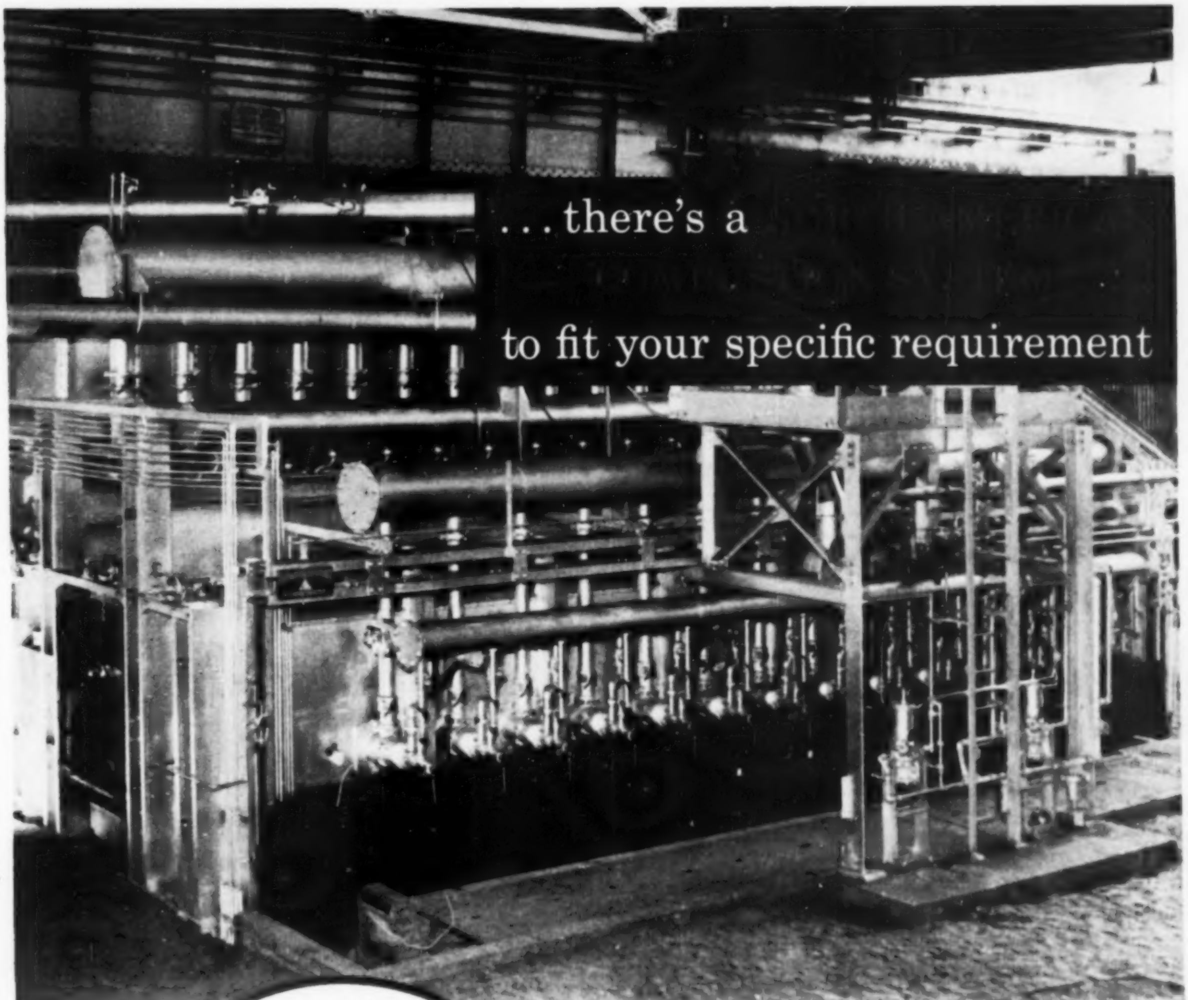
Curves developed for stress-rupture time and for stress-time for 1% total deformation indicate that all four alloys have similar rupture strengths up to about 20 hr. at 1000° F. and to 1 hr. at 1100° F. The strength of the 4340 steel wheel fell below the other alloys for longer time periods at these temperatures and for all periods at 1200° F. The "17-22 A"S wheel maintained rupture strength higher than or equal to the other alloys for time periods up to 1000 hr. at 1000° F., to 100 hr. at 1100 and 10 hr. at 1200. Little difference was observed in rupture strength between H-40 and C-422 wheels at 1000 and 1100° F. The former steel, however, gave substantially higher strengths at a temperature of 1200° F.

Relative strengths for a total deformation of 1% compared similarly to the rupture strengths, although the C-422 steel in general had slightly lower total deformation strengths than indicated by the stress-rupture strengths, due to relatively fast creep rates during first-stage creep.

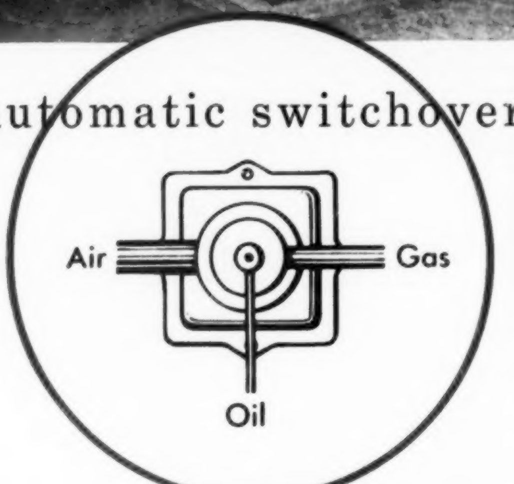
The wheels were to be produced to a hardness range of Brinell 280 to 320. Some difficulty was encountered in obtaining this hardness range. It was believed, however, that this could be corrected through more experience in producing and heat treating the alloys in the section sizes involved. Some evidence of low center ductility also was noted, again probably a function of manufacturing techniques and undoubtedly subject to betterment.

In summary, the extensive test data appear to indicate that the level of properties obtainable in the form of actual turbine wheels is sufficient to permit a choice of material and its proper proportioning with the usual safety factors of engineering design. In actual use of the alloys, metallurgists would be called upon to develop suitable practices and checks to insure uniform and as nearly optimum properties as possible for any particular alloy.

A. H. Allen



automatic switchover. . . . for DUAL-FUEL applications



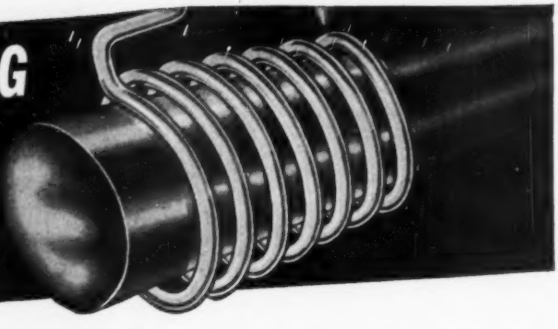
North American's outstanding contribution to combustion is the automatic dual-fuel switchover, to provide uninterrupted service wherever gas is supplemented by oil or vice versa.

A great safeguard in any industrial installation, dual-fuel is required by many utilities to protect all consumers in emergencies. As the originators of dual-fuel systems, NORTH AMERICAN engineers are the nation's specialists.

THE NORTH AMERICAN MANUFACTURING COMPANY

CLEVELAND 5, OHIO

YOU CAN HEAT *ANYTHING*
FROM A NEEDLE . . . TO
A TURBINE SHAFT
FASTER and BETTER



WITH *Lepel*

HIGH FREQUENCY
Induction
HEATING UNITS

BRAZING
Permits widest choice of silver or copper brazing alloys from lowest to highest melting points. Ideal for brazing carbide tips.

HARDENING
Heat localized exactly where wanted at desired temperature. Ideal for gears, cams, bearing surfaces, cutting tools and other areas that are subject to wear.

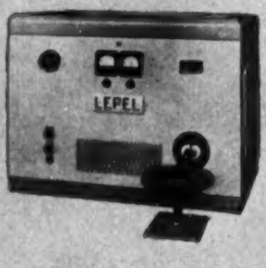
SOLDERING
Speedily and neatly performs intricate soldering applications with or without the use of preformed rings.

ANNEALING
Ideal for annealing, stress-relieving, normalizing or preheating selected areas.

MELTING
Readily melts quantities of ferrous and non-ferrous metals in either graphite or ceramic crucibles.

The Lepel line of induction heating units represents the most advanced thought in the field of electronics as well as the most practical and efficient source of heat yet developed for industrial heating. With a background of half a century of electrical and metallurgical experience, the name Lepel has become the symbol for quality in induction heating equipment embodying the highest standards of engineering achievement, dependable low cost operation and safety.

If you are interested in the application of induction heating you are invited to send samples of the work with specifications of the operations to be performed. Our engineers will process these samples and return the completed job with full data and recommendations without any cost or obligation.



2½ KW INDUCTION HEATING UNIT

30 KW INDUCTION HEATING UNIT

100 KW INDUCTION HEATING UNIT

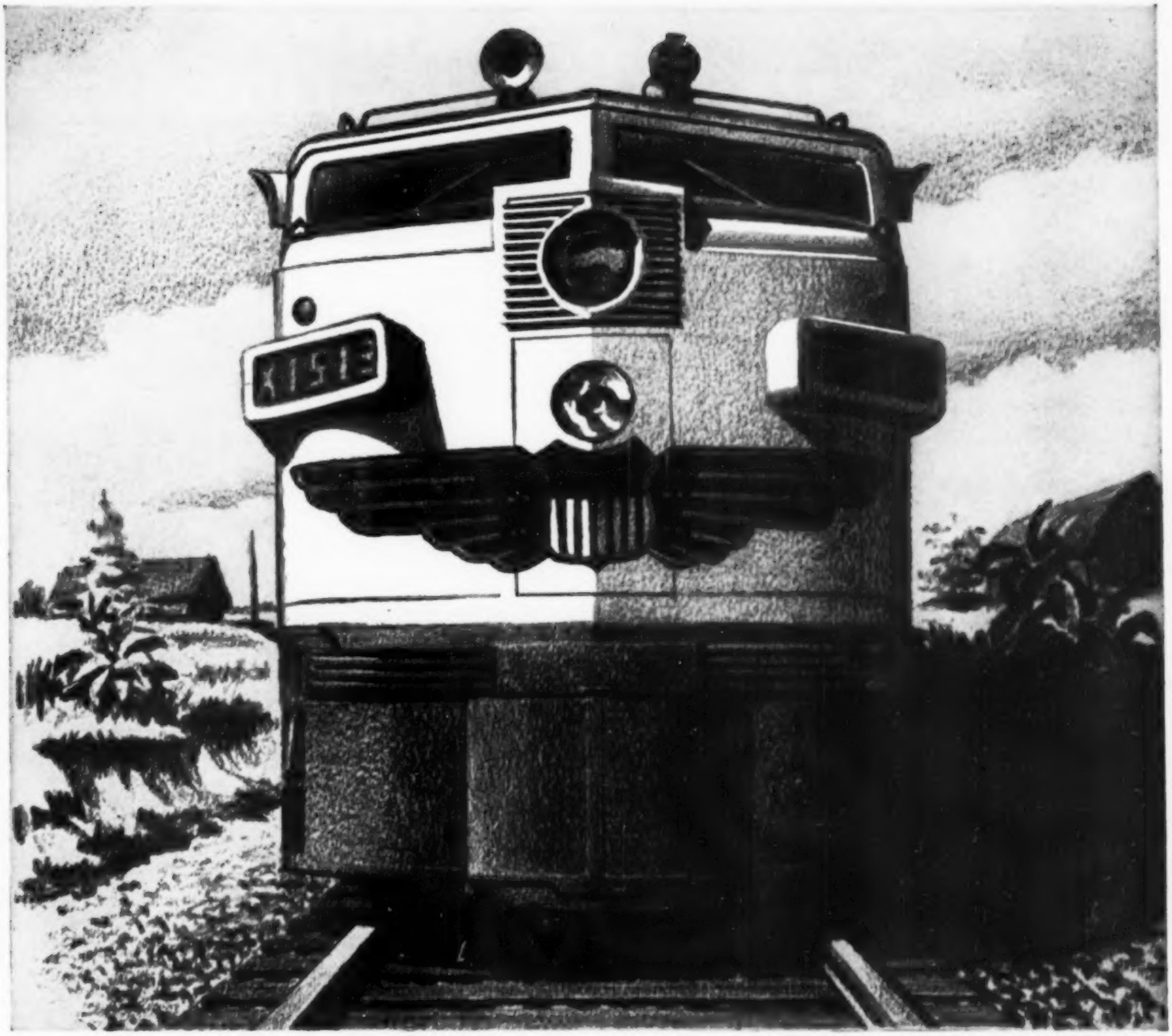
LEPEL Electronic Tube GENERATORS
1 KW; 2½ KW; 5 KW; 10 KW; 20 KW; 30 KW; 50 KW; 75 KW; 100 KW.

LEPEL Spark Gap Converters
2 KW; 4 KW; 7½ KW; 15 KW; 30 KW.

All Lepel equipment is certified to comply with the requirements of the Federal Communications Commission.

WRITE FOR THE NEW LEPEL CATALOG . . . 36 illustrated pages packed with valuable information on high frequency induction heating.

LEPEL HIGH FREQUENCY LABORATORIES, INC.
55th STREET and 37th AVENUE, WOODSIDE 77, NEW YORK CITY, N. Y.



Here's where heat and corrosion prove metal...and metallurgists

For castings subject to High Fluctuating Temperatures . . .

Waukesha No. 321 Titanium Stabilized Stainless Steel

Supercharger inlet ports in giant railroad diesels demand castings of unusual characteristics. They must be high in corrosion resistance, and must maintain this resistance under abnormally high temperature fluctuations. In addition, close tolerances demand easy machinability.

This is the kind of problem that naturally comes to Waukesha Metallurgists for laboratory solution. Waukesha No. 321 Stainless Steel with *titanium,* with carefully controlled modifications, offered a solution. Its effective use in castings requires a high degree of knowledge and skill both in formulation and in production, but Waukesha has succeeded in casting it for such critical uses as trays and conveyor parts for heat treating furnaces and other high temperature needs. Its adaption to G-E Supercharger inlet ports is another example of Waukesha's experience in serving industry with the more difficult alloys.

Have You a Castings Problem?

Take this opportunity to prove Waukesha's advanced metallurgical service — to your profit! Send us a pattern for sample casting. Or write for booklets containing current data on Waukesha Stainless Steel and "Waukesha Metal".

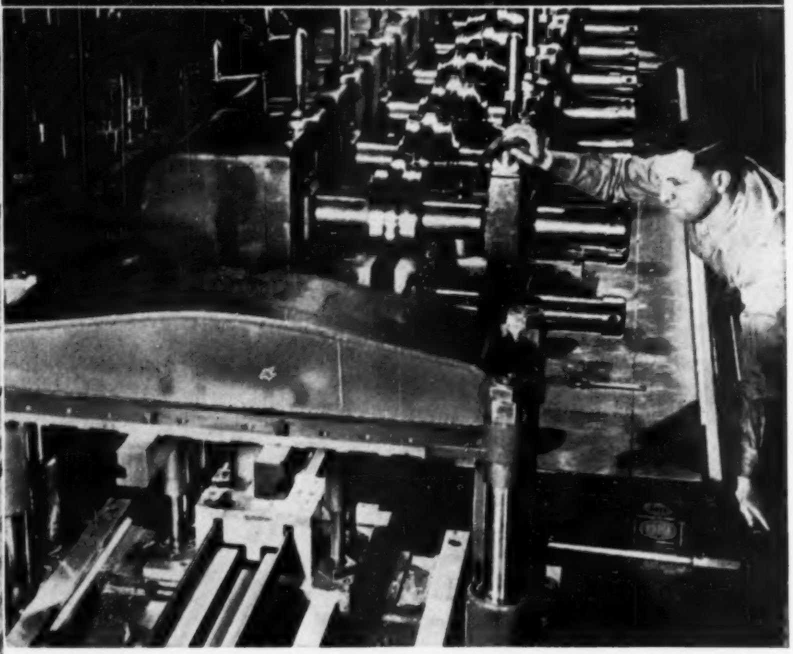
call Waukesha first . . .

WAUKESHA FOUNDRY CO.

5404 LINCOLN AVE., WAUKESHA, WISCONSIN

For Metallurgical Aid in Every Corrosion Resistant Alloy

Cold-Roll-Forming



simplest, fastest, most economical—

In the assembly of your products, to the wide extent that cold-roll-formed components can be used, substantial economies can be effected.

A Yoder Cold-Roll-Forming Machine with one operator and a helper will make upwards of 30,000 feet per day. Thus the cost usually is only a small fraction of a cent per foot for converting strip into structural shapes, trim, mouldings, panels, tubular or box shapes.

The machine may, therefore, be highly profitable even if operated only a few days per month. After you install it for a given purpose, you are likely to discover other things which can be done better and more cheaply on it than by methods heretofore employed.

You may also find it practical to combine other operations with cold-forming, such as curving, coiling, embossing, welding, perforating, notching, etc., at little or no extra labor cost. Yoder engineers are always glad to assist in making up such multi-function production lines.

The Yoder Book on Cold Roll Forming is a valuable source of information on the scope, mechanics and economics of the art. Send for free copy.

THE YODER COMPANY • 5595 Walworth Ave., Cleveland 2, Ohio

Complete Production Lines

ENGINEERING YODER MANUFACTURING

★ **COLD-ROLL-FORMING and auxiliary machinery**
★ **GANG SLITTING LINES for Coils and Sheets**
★ **PIPE and TUBE MILLS — cold forming and welding**

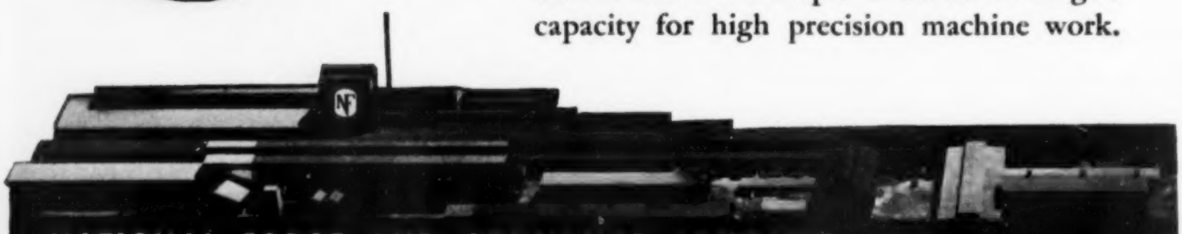
Real "PULL"

...3,000,000 Lbs. Worth

These forgings are fixtures for an enormous testing device that can exert 3,000,000 lbs. pull. They were forged and precision machined at NATIONAL FORGE to very close tolerances. As an example, there is less than .003 in. play in the threads top and bottom combined — considerably less than the specifications called for. To the customer, it means testing data will be more accurate and informative.

No matter what type of machining you require, whether large or small, simple or intricate, National Forge has the equipment and experience to turn it out to your complete satisfaction.

This is another example of National Forge's capacity for high precision machine work.



NATIONAL FORGE AND ORDNANCE COMPANY

PRODUCES BETTER STEEL FORGINGS AND MACHINE WORK

IRVINE, WARREN COUNTY, PENNSYLVANIA

Short Cycle Annealing For Cold Extrusion

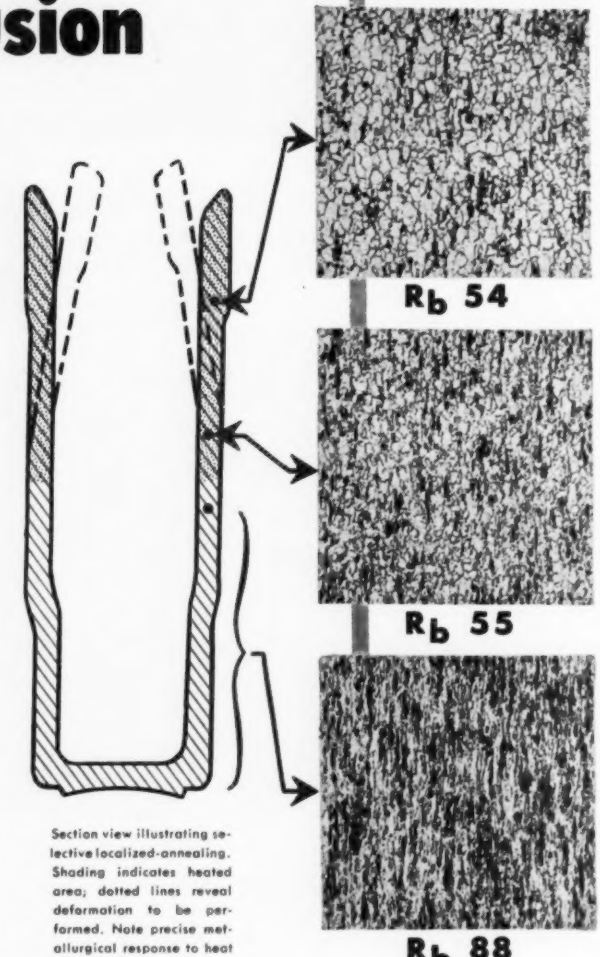
Considerable interest is being exhibited in metalworking today in forming steel into desired shapes by cold extrusion, resulting in improved products in terms of cost, quality and metal conservation.

Cold extrusion, applied mainly to large-scale production of ammunition components at present, is geared for application to a wide variety of commercial products. In major installations, conveyors and specially designed work-handling devices have aided in speeding up the production line to permit economic processing. One of the serious bottlenecks in this overall scheme of automation has been the long annealing treatments applied at different stages of the cold forming. In usual practice the parts are stacked in alloy baskets and annealed under an atmosphere or in salt baths to avoid scaling. Soaking time, for temperature uniformity, may range from 20 to 45 minutes, with the total time under heat running to double those figures.

A recent installation of six Selas continuous furnaces in the new cold extrusion plant of the Heintz Manufacturing Company extends the trend of automation to include annealing, by placing the heat treating operation into the production line. The work pieces are conveyed singly on rotating spindles through the high speed heating (and cooling) cycles, being loaded and unloaded at the same station. Total time under heat is only seven minutes and under forced air cooling is nine minutes, for a normal production rate of 350 pieces per hour per furnace.

The precise control of furnace temperature and heating time insures uniformity of anneal within each workpiece and from piece to piece. No prepared atmosphere is required since the products of controlled gas-air combustion, surrounding the work piece (with no free-oxygen present), coupled with the short heating time, minimize surface oxidation. Removal by flash pickling produces a superior surface which is excellent for subsequent phosphate coating lubrication treatments.

Extensive testing in the development stage of this heating process, preceeding furnace design and construction, confirmed that short-cycle annealing, with no soak, produces hardness patterns and structures identical to those obtained in conventional processing under longer cycles with soaking.

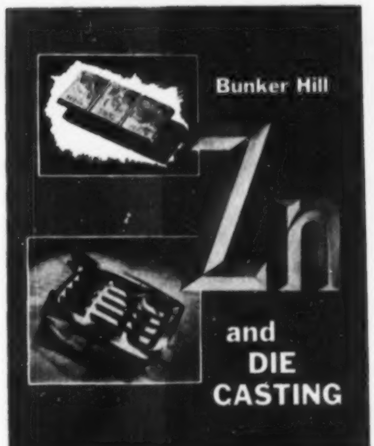


Section view illustrating selective localized-annealing. Shading indicates heated area; dotted lines reveal deformation to be performed. Note precise metallurgical response to heat processing method.

The continuous, radiant-heat furnaces are readily adaptable to selective localized heating where required. In the accompanying illustration, 4" of the mouth end of a drawn and coined rocket projectile has been softened for cold-nosing without disturbing the physical properties of the base portion. This feature permits greater overall freedom in establishing production operations to attain desired metal-flow or end-product metallurgical properties. The build-in versatility of these furnaces permits annealing of projectiles of varying sizes and shapes.

Selas Corporation of America
Philadelphia 34, Penna.

HERE is the story of.....



DIE CASTING
as a high-speed, low-cost production tool

ZINC
and its advantages as a base metal for die castings

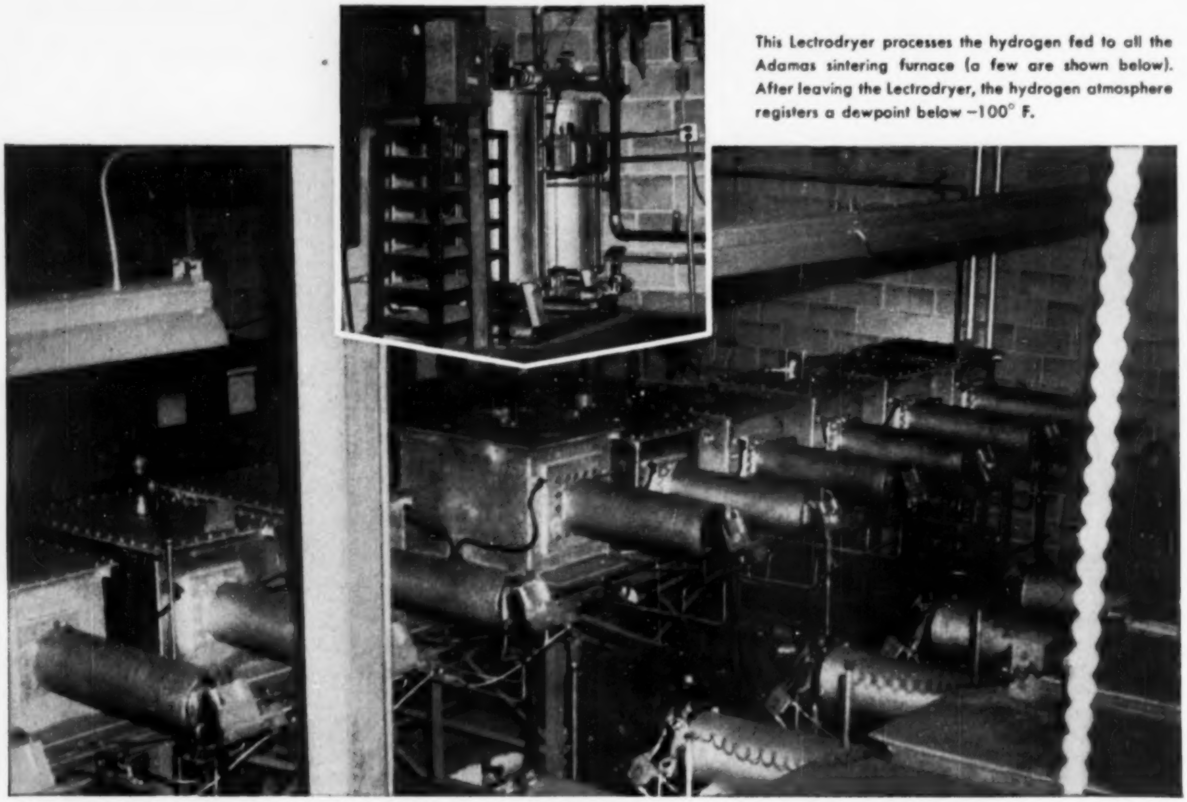
BUNKER HILL'S
contribution to the phenomenal growth of the die casting industry

This new 8½ x 11", 24-page publication is yours for the asking. Write for copy on your company letterhead please.

ST. JOSEPH LEAD COMPANY
250 PARK AVENUE
NEW YORK 17, N.Y.

THE LARGEST PRODUCER OF LEAD IN THE UNITED STATES

This Lectrodryer processes the hydrogen fed to all the Adamas sintering furnace (a few are shown below). After leaving the Lectrodryer, the hydrogen atmosphere registers a dewpoint below −100° F.



Adamas Carbide insists on DRY hydrogen for sintering

A hydrogen dried to a dewpoint below −100° F prevents surface oxidizing of carbides being sintered at Adamas Carbide Corporation's ultramodern plant at Kenilworth, New Jersey.

To obtain such dryness, Adamas follows two steps:

(1) The hydrogen feeds through a catalytic cylinder which converts every trace of free oxygen into moisture.

(2) Then the hydrogen passes through a Lectrodryer* which snatches moisture from the gas, delivering it at a dewpoint somewhere below −100° F.

You can obtain similar dryness

Lectrodryers will economically remove unwanted moisture from air or other gases in a continuous, automatic cycle. For large or small volume—low or high pressures (to 6000 psi)—Lectrodryers of all types and sizes are available to solve your problem.

Talk it over with a Lectrodryer engineer. No obligation, and he may help you considerably. Write for the booklet, *Because Moisture Isn't Pink*, describing how industry is using Lectrodryers. Pittsburgh Lectrodryer Corporation, 317 32nd Street, Pittsburgh 30, Pa.

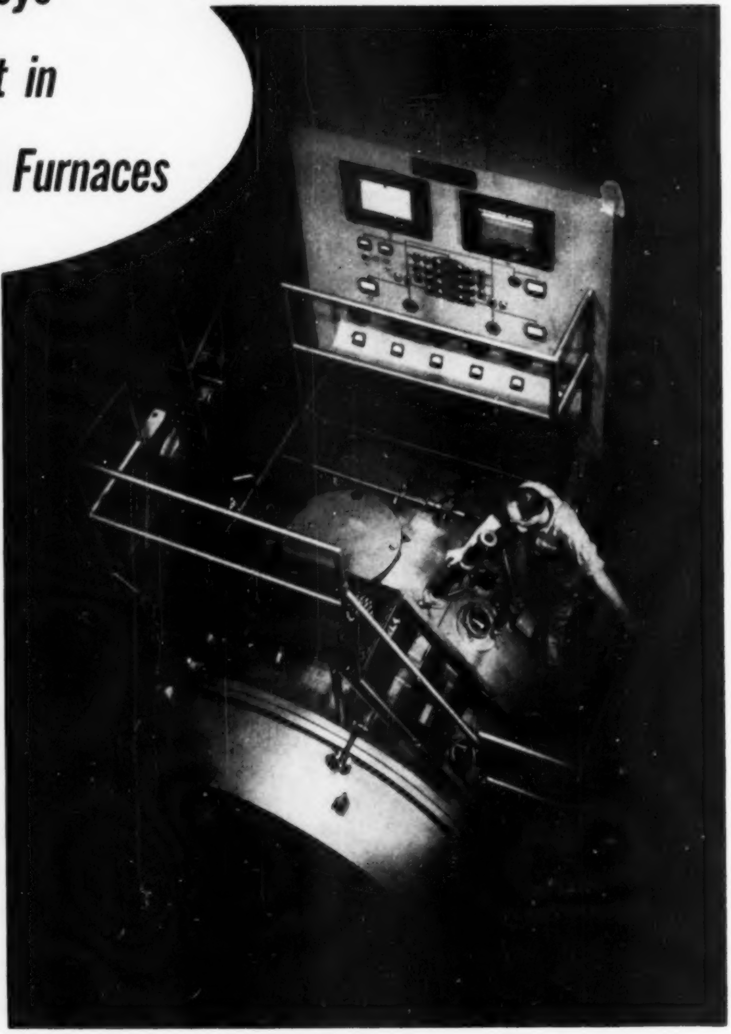
In England: Birlec, Limited, Tyburn Road, Erdington, Birmingham.
In France: Stein et Roubaix, 24 Rue Erlanger, Paris XVI.
In Belgium: S. A. Belge Stein et Roubaix, 320 Rue du Moulin, Bressoux-Liege.

LECTRODRYERS DRY WITH ACTIVATED ALUMINAS

LECTRODRYER

* REGISTERED TRADEMARK U.S. PAT. OFF.

High-temperature Alloys now Melted and Cast in Stokes High-Vacuum Furnaces



A Stokes high-vacuum melting furnace of 1000-pound capacity at Utica Drop Forge & Tool Corporation, Utica, N. Y. The furnace is to be used for the melting and casting of high-temperature alloys for jet engine rotor blades.

Vacuum furnace melting and casting is the economical method for producing many new metals, with greatly improved properties. Alloys that can stand up in rocket engine combustion chambers and advanced jet engine turbines, metals essential for the construction of nuclear reactors, still other high-purity metals with properties not previously attainable . . . these are just a few of the more than thirty new elements vacuum processing has added to the industrial spectrum.

Vacuum-melted high alloy steels have greater tensile, yield, and impact strengths than conventionally-processed metal, plus greater stress-rupture strength at elevated temperatures, less creep, less brittleness. High-purity iron, processed in vacuum, has 60 to 75% greater stress-rupture strength and 400% more elongation than conventional metal. In anti-friction bearings, vacuum-processed steel has shown an increase of 300% or more in fatigue strength, and given a whole new perspective to the subject of wear-resistance.

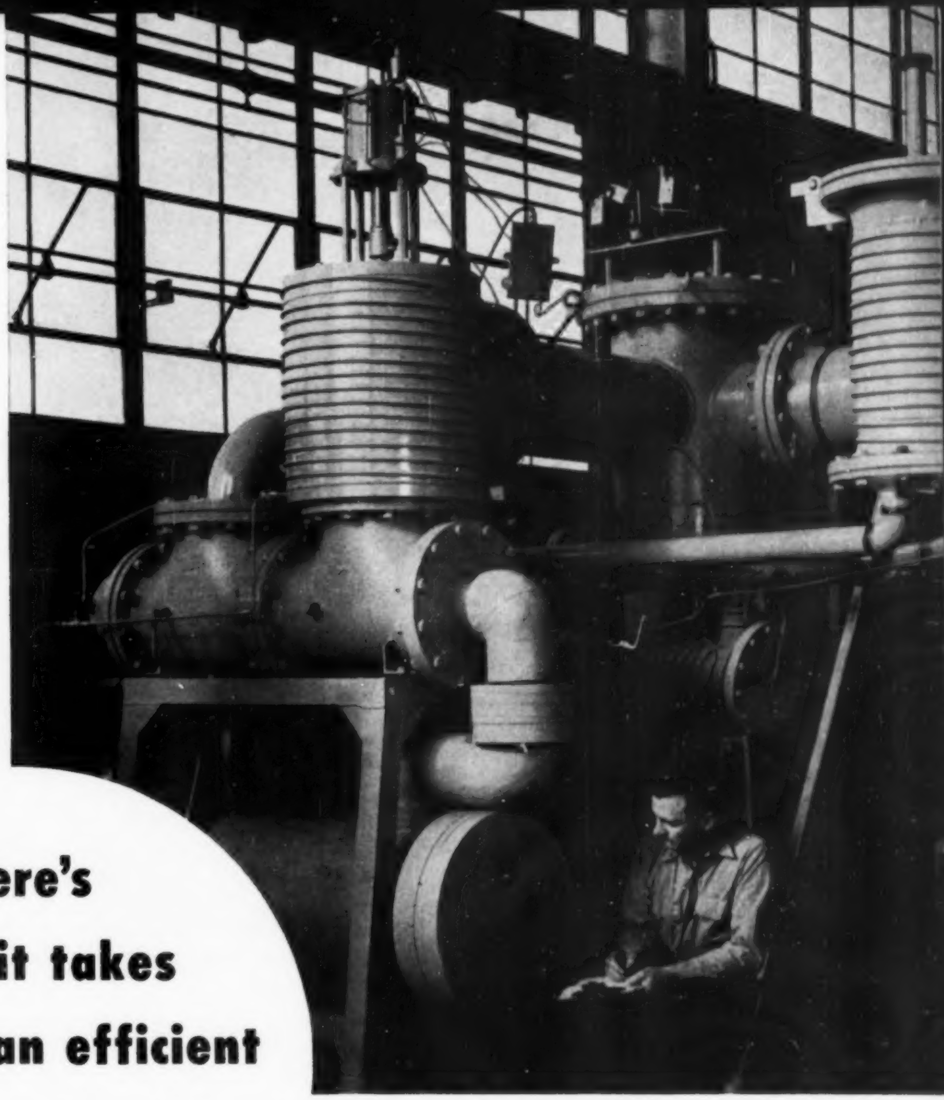
Moreover, vacuum processing of alloys conserves critical hardening elements, since there is minimum loss of these metals during melting. More usable metal is obtained from each melt, and virtually all of the scrap can be salvaged by vacuum melting.

Stokes is *building* vacuum furnaces to process these high-purity metals in quantities up to 2000 pounds, and *planning* 5000-pound units. Stokes vacuum furnaces reflect the practical experience accumulated in fifty years of building vacuum equipment. An interesting NEW brochure is ready for mailing on request!

F. J. Stokes Machine Company
Philadelphia 20, Pa.

STOKES

STOKES MAKES: High Vacuum Equipment, Vacuum Pumps and Gages / Industrial Tabletting, Powder Metal and Plastics Molding Presses / Pharmaceutical Equipment



UNICHROME
Trade Mark

News about

COATINGS for METALS

Metallic . . . . Organic . . . . Decorative . . . . Protective

New-Type Finishes Solve Metal Protection Problems

Unique groups of Unichrome Organic Coatings meet tough specifications—deliver unusual performance

United Chromium cooperates in working out answers to service and production requirements for metal finishes.

DIFFICULT problems of protecting various metals from corrosion with organic finishes can today be readily solved by means of new and unusual Unichrome Coatings. The finishes include plastisol coatings; eye-appealing coatings which are also in the highly corrosion resistant class; primers.

PLASTISOL USAGE PAYS

Unichrome Vinyl Plastisols are liquids or pastes with 100% solids. Cured at 350°F, they develop coatings with the best features of inert plastics and rubber. They deliver the unique combination of wide chemical resistance, resiliency, thick build-up on the part, and seam-free, pore-free protection.

Various types available now include practical *sprayable* compounds which deliver films up to 25 mils thick in a *single* sag-free coat.

These coatings are establishing remarkable service records. They often permit use of ordinary metals in place of costly alloys. For example: Half-ton stainless steel strainer bodies were replaced by plastisol-coated cast iron because of the remarkable chemical protection afforded by the finish. Applied to bleach reduction chambers, the Unichrome Plastisol Coating gave four times longer service than special alloy metal before needing maintenance.

MORE DURABLE FINISH

To simulate gold parts for refrigerator trim, one company used polished stainless steel and a Unichrome Transparent Tinted Enamel – which passed the 500 hour heat and humidity test and was still going strong 11,850 hours later. Tinted coatings with such durability can be used for other metals, too, for a finish that looks better longer.

PRIMER FOR LIGHT METALS

Wider use of magnesium and aluminum can now be made because finishing them need no longer be a problem. Unichrome Primer AP-10 assures dependable adhesion of top coats to these active metals. Rigorous tests by large metal producers proved it, usage has confirmed it.

* * *

These coatings exemplify a few of the specialized coatings United Chromium has developed to deliver exceptional performance on metal products. Send in the details on your requirements.

HELPFUL HINTS

by "Mr. Cost Cutter"

The shape of a piece can greatly affect the uniformity of its plated finish —sometimes even determines whether it can be economically plated at all. It pays, therefore, to check with the finishing department to learn whether any newly designed part to be plated will create problems which could cause many rejects and high finishing costs. If such is the case, minor changes can often be made which will avoid the problems in the *design* stage.

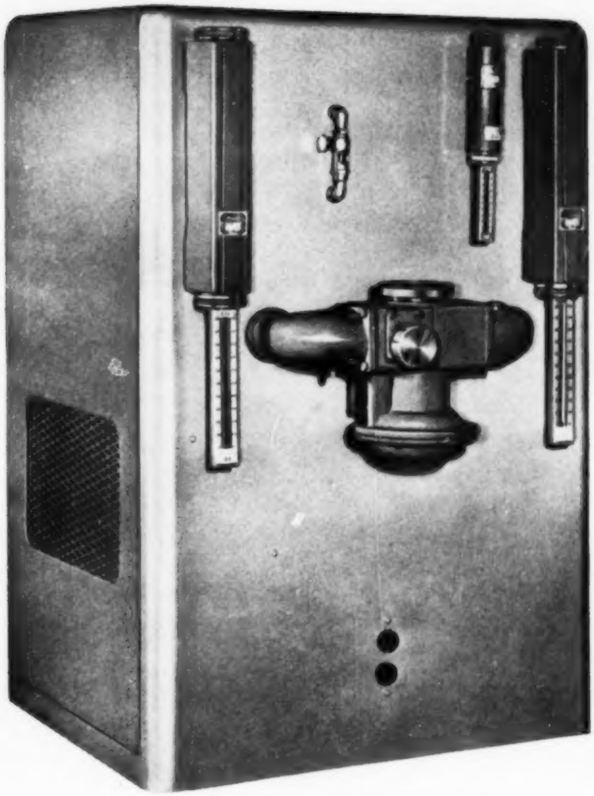
More tolerant nickel bath = more output

A plant installed the Unichrome Bright Nickel process alongside a larger tank of another nickel solution. Both plated identical parts. Yet Unichrome Nickel turned out more work. It tolerated impurities so much better that it took less time for purification. Now it occupies both tanks. Ask for bulletin NI-1.

NEW IMPROVEMENTS IN COPPER PLATING

New addition agents for use with Unichrome Pyrophosphate Copper Plating Solution have eliminated buffing for many users, made it easier for others who prefer to buff copper rather than the base metal or subsequent deposits. This is due to still finer grain and smoother deposits assured by the agents—which makes this copper also ideal for stop-off work in nitriding and carburizing operations. Use of the agents has also increased plating speed—as much as 20% in some cases.

UNITED CHROMIUM, INCORPORATED
100 East 42nd Street, New York 17, N. Y.
Detroit 20, Mich. • Waterbury 20, Conn.
Chicago 4, Ill. • Los Angeles 13, Calif.
In Canada:
United Chromium Limited, Toronto 1, Ont.



The clean functional design of The Waukee MIXOR enhances its operational efficiency.

This is the new WAUKEE MIXOR

Here are some of its exclusive features:

CARBURETOR EASILY CLEANED. The carburetor can be disassembled, cleaned and put back together in five minutes, using an ordinary screw driver, without disturbing the ratio setting.

CARBURETOR CAP. Glass insert in the top clearly shows when cleaning is necessary.

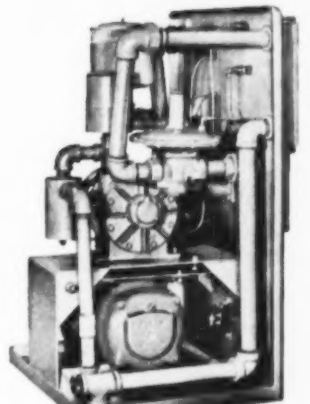
CONVENIENT SIGHT FEED INDICATOR. Sight feed indicator on the panel front where it can be easily seen, easily used, prevents under-oiling or over-oiling.

USES STANDARD MOTOR. Uses standard 1750 R.P.M. motor. This feature eliminates excessive down-time required for servicing or replacing special motors.

New Precision, Efficiency and Convenience for Gas-Air Mixing

Here is a great new achievement by the makers of the famous Waukee Flo-Meters—a packaged mixing machine that will provide you precise control of gas-air ratios. For mixing city gas, natural gas, propane, butane and air. The Waukee MIXOR is designed for use on gas generators of the endothermic and exothermic types and is ideally suited for producing gas-air mixtures for flame hardening, torch brazing, torch annealing and soft metal melting.

Made in 3 sizes: 400 ft. per hour, 600 ft. per hour, and 1500 ft. per hour. Available for mixing city gas, natural gas, propane, butane and air. We are ready to take care of your requirements, or ask for Bulletin 400.

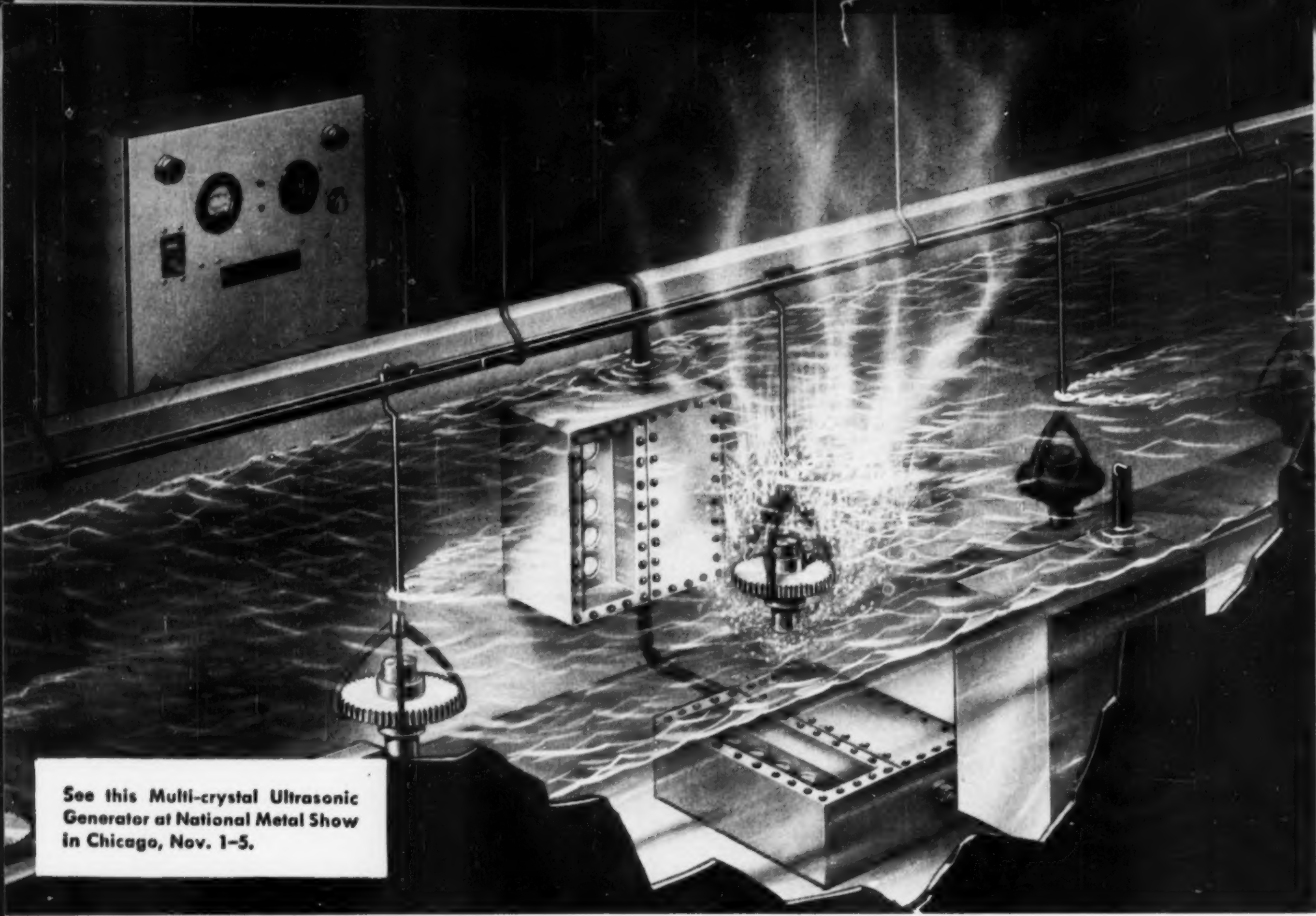


A COMPLETE UNIT. Supplied with vane-type compressor, standard motor with V-Belt drive, motor adjusting base, air filter, pressure relief valve, gas zero governor, lubricator, carburetor and Flo-Meters mounted and factory piped.

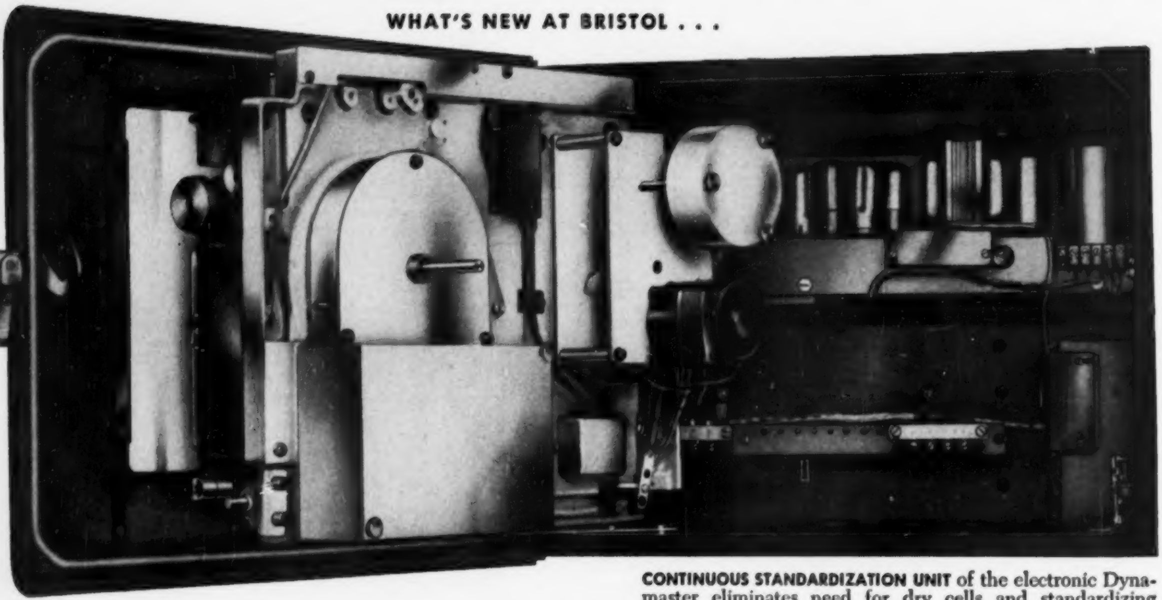
Waukee ENGINEERING COMPANY

403 E. Michigan Street • Milwaukee 2, Wisconsin

Detroit and Cleveland • H. E. Ardahl, 4448 Bishop, Detroit 24, Michigan


See this Multi-crystal Ultrasonic Generator at National Metal Show in Chicago, Nov. 1–5.

WHAT'S NEW AT BRISTOL . . .



CONTINUOUS STANDARDIZATION UNIT of the electronic Dynamaster eliminates need for dry cells and standardizing mechanism. Result: no interruptions in the operation of the potentiometer for standardization; no batteries to replace.

No time out for standardization here

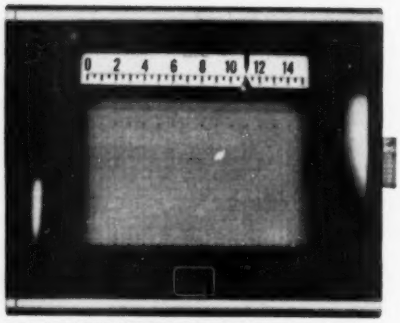
Bristol Dynamaster potentiometer pyrometers give you No-Batt continuous standardization

• You don't have to put up with interrupted performance from old-fashioned potentiometer pyrometers any longer!

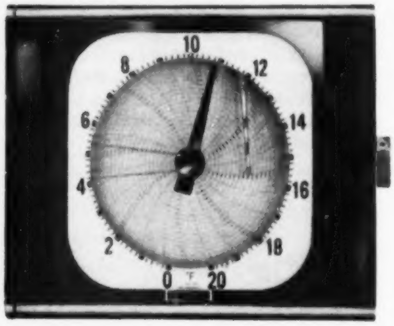
When you use a Bristol thermocouple or radiation-type Dynamaster, you get a *continuous* record or control of temperatures up to 4000°F in any type of fuel-fired or electric furnace or heating equipment. Thanks to the exclusive No-Batt continuous standardization which eliminates the need for dry cells in these electronic instruments, Bristol has been able to do away with interruptions formerly required for periodic standardization.

Bristol electronic Dynamasters are made in round- and strip-chart, single- and multiple-record recorders, air-operated and electric controllers with all types of control actions. Two-pen and program control.

For the complete story on the modern human-engineered Bristol Dynamaster, write for free 35-page booklet P1245. The Bristol Company, 106 Bristol Road, Waterbury 20, Conn.



BRISTOL DYNAMASTER CONTROLLERS in either the strip-chart model (shown above) or round-chart model, may be electrically or air operated. 2 position, 3 position, proportional, manual with automatic reset, or proportional input controls. On - off, proportional or reset air controls.



BRISTOL DYNAMASTER RECORDERS come in easy-to-read round-chart (shown here) or strip-chart models. Single record, multiple record or continuous 2 record designs are available. Bristol also supplies all types of time-temperature program controllers.

BRISTOL

POINTS THE WAY IN HUMAN-ENGINEERED INSTRUMENTATION

AUTOMATIC CONTROLLING, RECORDING AND TELEMETERING INSTRUMENTS

NRC Vacuum Furnace in operation

Here's why you're Way Ahead

Laboratory Model NRC Vacuum Furnace

with an NRC Vacuum Furnace

Whether you're melting laboratory lots of titanium or casting special alloys by the ton, your production is faster, simpler and more economical when you use an NRC Vacuum Furnace, because National Research has built more vacuum furnaces than *any other company in the world.*

Installations ranging in size from a few pounds to many tons, multi-purpose furnaces designed for maximum flexibility in experimental work, special purpose designs, standard pilot plant furnaces and production units . . . all are built by National Research Corporation, adding to every design the benefit of unequalled experience in this complex field.

Full and interesting information about NRC Vacuum Furnaces is in the new "Vacuum Furnace Bulletin." Write for your copy today.

NRC

NARESCO EQUIPMENT CORPORATION

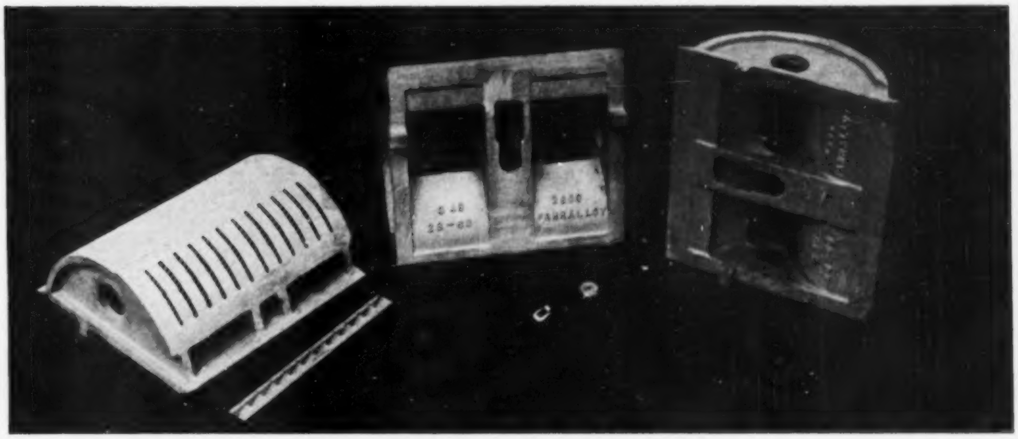
Equipment Sales Subsidiary of NATIONAL RESEARCH CORPORATION 160 Charlemont Street, Newton Highlands 61, Mass.

OFFICES: BOSTON · PALO ALTO · CHICAGO · CLEVELAND · NEW YORK · PHILADELPHIA

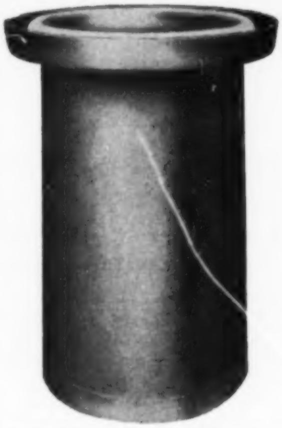
WHERE THERE'S HEAT THERE'S FAHRALLOY

FAHRALLOY...

versatility means better heat and corrosion resisting alloy products for you



Recuperator Liner for Cement Mill Cooler



Retort for Pit Type Carburizer

DURING the more than 20 years that Fahralloy has been producing heat and corrosion resisting alloy castings for industry, versatility has been a keynote of the company's operations . . . versatility in design, in size, in composition to meet each individual need. Fahralloy thinking has always been in terms of solving heat and corrosion problems. That's why Fahralloy castings assure better service and longer life. When you have a problem that involves the toughest of high temperature service conditions, you can have complete confidence that you will find the solution at Fahralloy.

•

CLARE CHARRON • 209 Curtis Building • Trinity 5-7633
DETROIT Area Representative

•

THE FAHRALLOY CO.

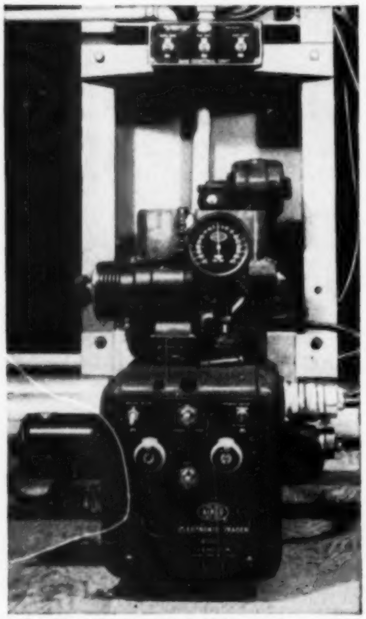
150th & Lexington Ave. — Harvey, Illinois

In Canada — Fahralloy Canada, Ltd., Orillia, Ontario

see it in operation at the Metal Show . . . Airco Booth #341

The NEW AIRCO #48 DUOGRAPH

the first rectilinear shape cutting machine that gives you the accuracy you want . . . at a price you can afford



▲ **CHOICE OF 3 TRACERS.** Use the sure, accurate Airco Electronic Tracer, the magnetic tracer, or manual tracer, according to type of work. Tracer equipment is interchangeable.

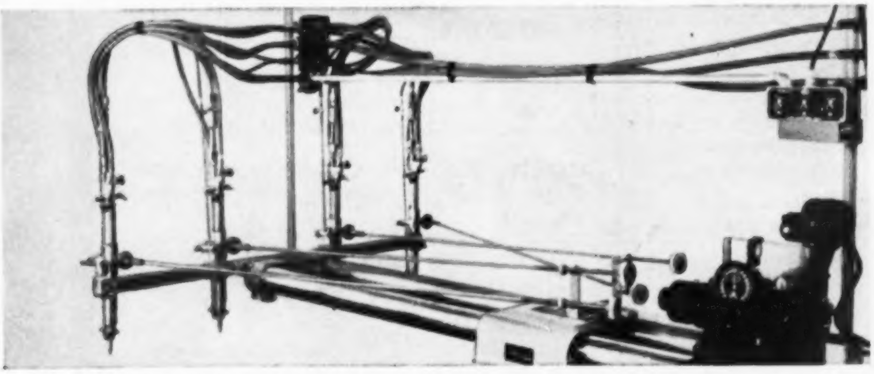
$3450*

featuring:

- **48" x 51" cutting area (one table)**
- **up to 4-torch operation**
- **centralized controls**
- **gas-saving solenoid valves**
- **accurate cuts**

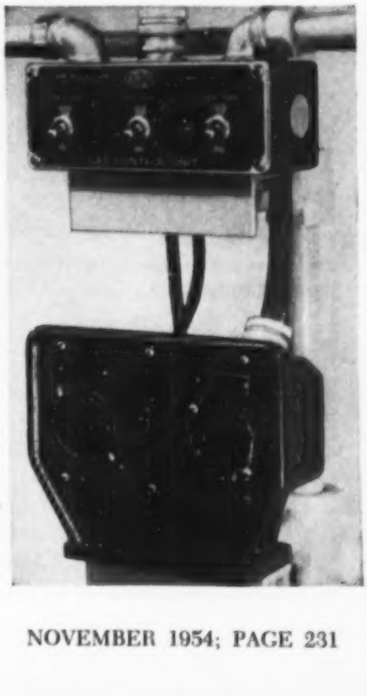
***Includes:** Complete machine with 2 torches • ten Airco #45 high speed cutting tips • manual tracer • solenoid controlled gas distribution system • straight edge • radius rod • hose supports • tracing table • hose to torches

Other equipment available: Airco Electronic Tracer • Airco Magnetic Tracer • 2 additional torches • additional tracing table



▲ **MOUNTS UP TO 4 TORCHES.** Torches clamp on mounting bar as illustrated. Easily positioned — 2 at left, 2 at right.

SOLENOID OPERATION — CENTRALIZED CONTROLS. Solenoid valve control saves gas. All controls grouped in central operation position — saves steps, speeds work. ▶



More *modern* Industries

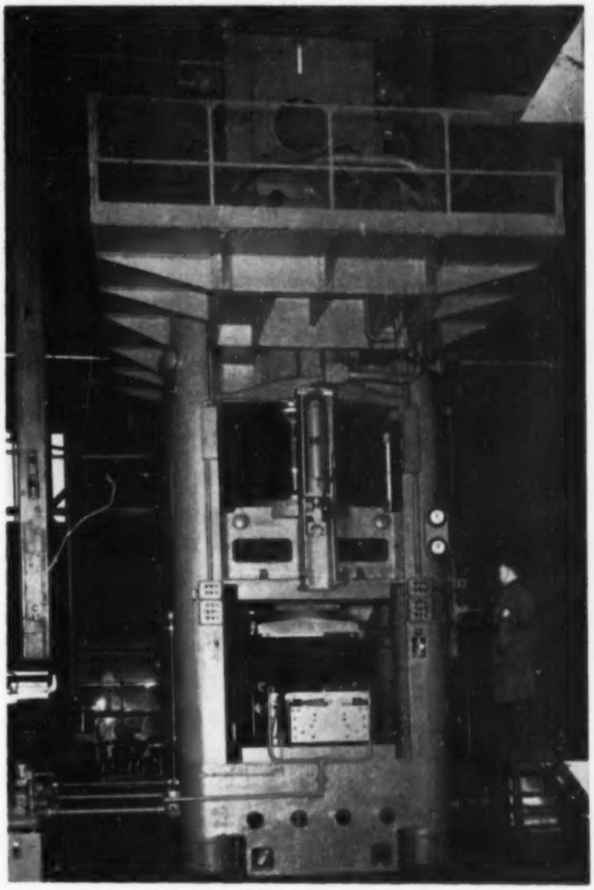
than ever before are now specifying

ACIPCO STEEL

Centrifugally Spun

TUBES for . . .

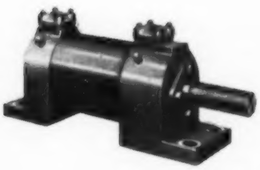
- ALL TYPES OF ROLLS
- HYDRAULIC CYLINDERS
- FURNACE TUBES
- CHEMICAL RETORTS
- MANY OTHER INDUSTRIAL APPLICATIONS



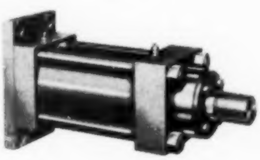
NEEDLESS TO SAY, the hydraulic press shown above and others like it must be built to withstand a lot of rugged punishment. Many of these industrial giants employ various types of hydraulic cylinders constructed of, ACIPCO STEEL centrifugally spun tubes for shuttle feed use and the like.

ACIPCO STEEL tubes are serving in countless industrial uses and their exceptional value as a component in weldment applications is widely recognized. Tubes can be furnished in all the alloy grades including heat and corrosion resistant stainless steels as well as plain carbon grades. Special non-standard analyses are also available. ACIPCO tubes are manufactured in lengths up to 16 feet with wall thicknesses from .25" to 4". Outside diameters range from 2.25" to 50" and in large sizes ACIPCO tubes have a decided economical advantage over hollow-bored forgings.

In ACIPCO tubes there is an absence of directional lines of weakness found in hot rolled or cold drawn tubing. Tubes can be furnished rough as-cast, finished machined or honed to your specific need.



ACIPCO STEEL centrifugally spun tubes were employed in the construction of the 3000 psi (above) and 2000 psi (below) hydraulic cylinders.



AMERICAN CAST IRON PIPE COMPANY

Special Products Division
Birmingham 2, Alabama

Distributors:

Austin-Hastings Company, Inc.
226 Binney Street
Cambridge 42, Massachusetts

Peter A. Frasse and Co., Inc.
17 Grand Street
New York 13, New York

Strong, Carlisle & Hammond Co.
1392 West Third Street
Cleveland 13, Ohio

Lyman Tube and Bearings, Ltd.
920 Ste. Sophie Lane
Montreal 3, Canada

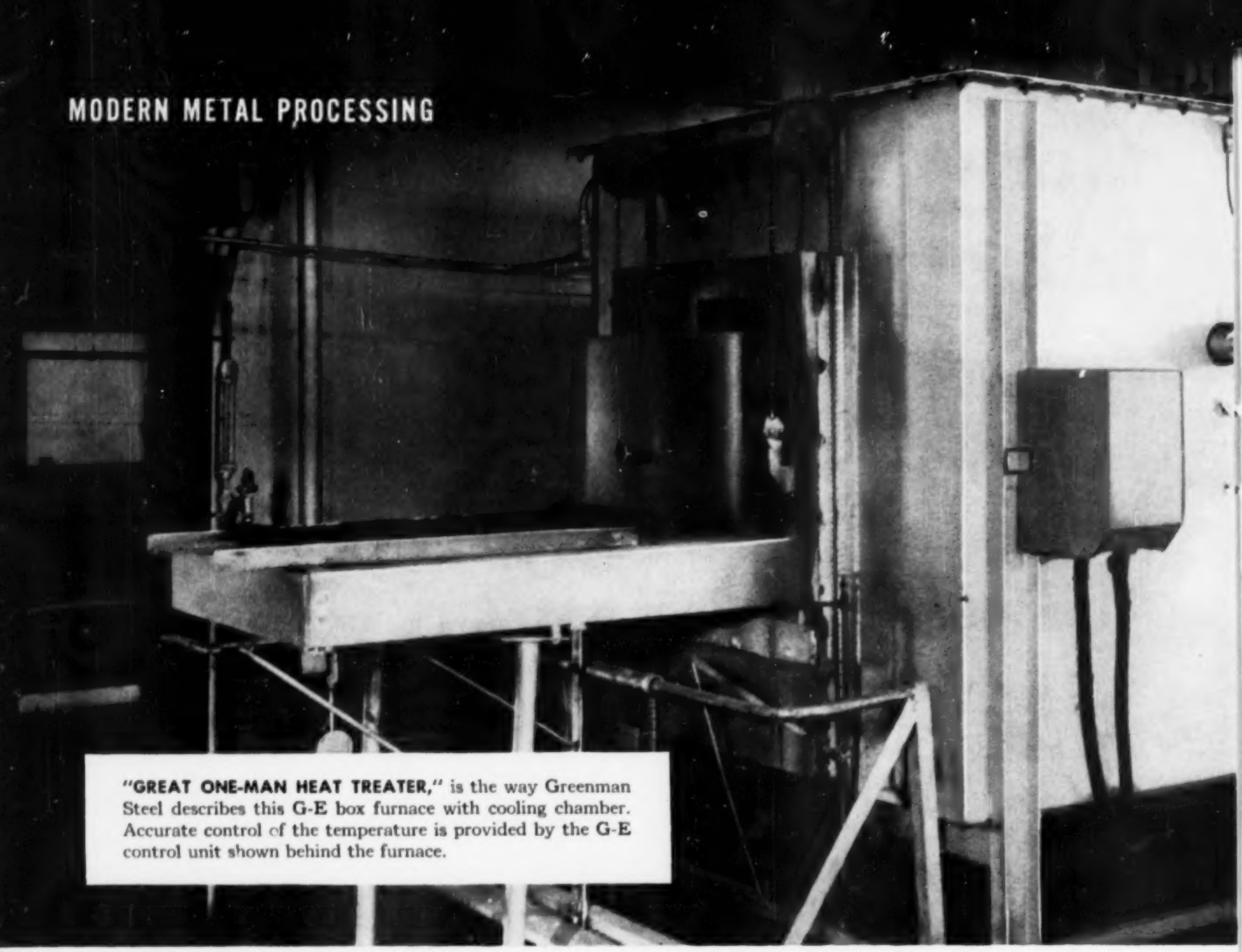
J. M. Tull Metal and Supply Co.
285 Marietta Street, N.W.
Atlanta, Georgia

Ducommun Metals & Supply Co.
4890 South Alameda Street
Los Angeles 54, California

C. A. Roberts Company
20 South Aberdeen Street
Chicago 7, Illinois

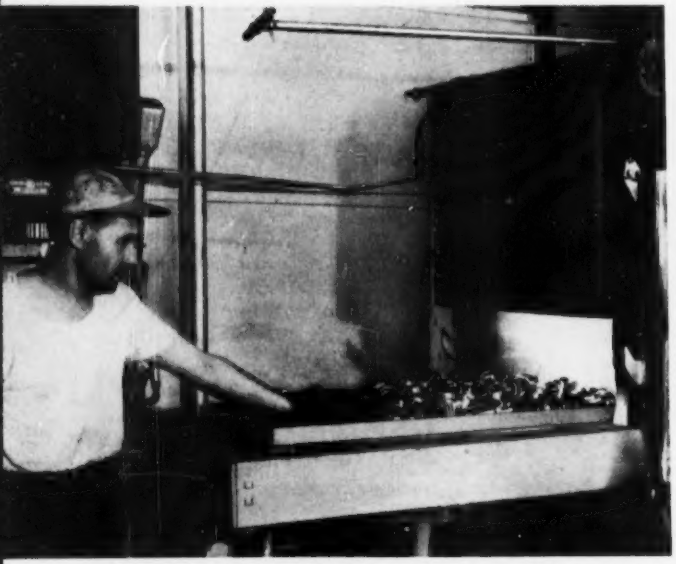
T. E. Rybka
South Park Road—R.D. 4
Library, Pennsylvania

NOW AVAILABLE without charge. "ACIPCO STEEL Centrifugally Spun Tubes"—a new 16mm sound motion picture in color (33½ minutes) showing ACIPCO's centrifugal tube-making process. Write ACIPCO, P. O. Box 2603, Birmingham 2, Alabama.

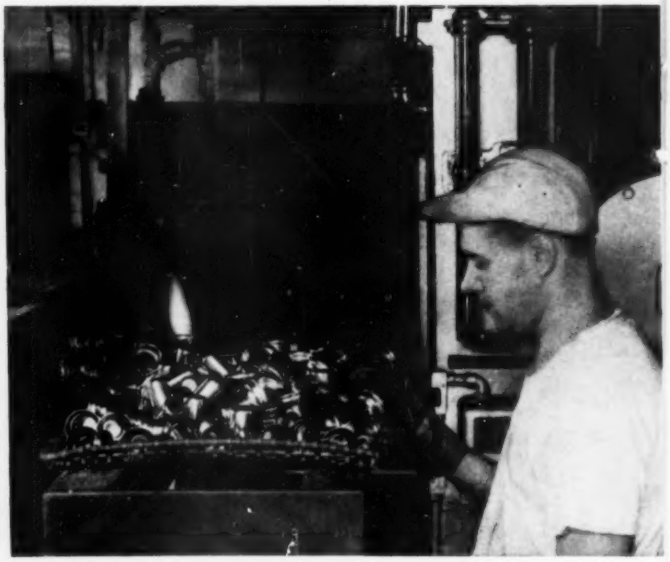


"GREAT ONE-MAN HEAT TREATER," is the way Greenman Steel describes this G-E box furnace with cooling chamber. Accurate control of the temperature is provided by the G-E control unit shown behind the furnace.

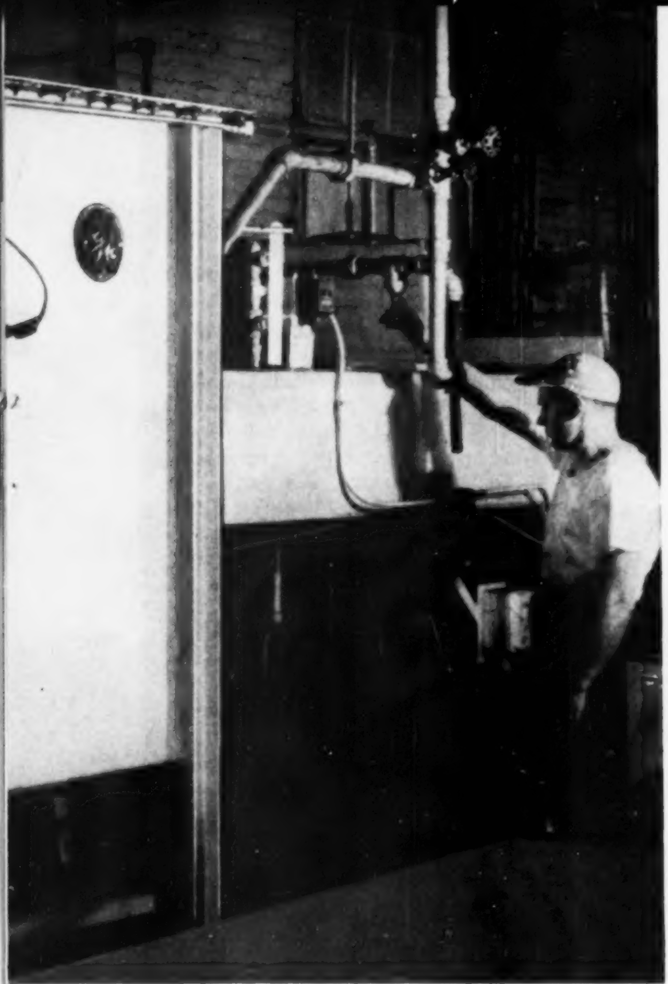
"Versatility of G-E Furnace Almost

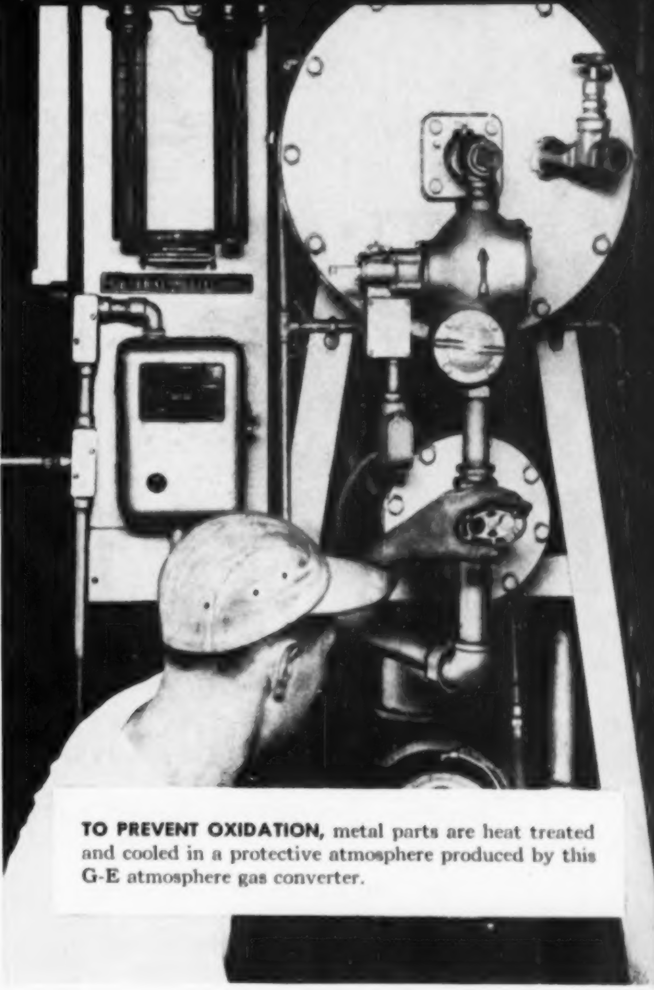


MANY HEAT-TREATING JOBS can be done with this one G-E box furnace. Greenman Steel uses it for copper brazing, silver brazing, annealing, and hardening. Here, the furnace is employed to anneal drawn-steel cups.



HIGH-QUALITY WORK is achieved by moving the parts directly from the furnace to the atmosphere cooling chamber, thereby minimizing oxidation. Here, the parts emerge from the cooling chamber clean and bright.





TO PREVENT OXIDATION, metal parts are heat treated and cooled in a protective atmosphere produced by this G-E atmosphere gas converter.

Unlimited," Says Industrial Heat Treater

Operational savings of G-E furnace keep Greenman Steel competitive

Heat-treating jobbers who demand versatility in a furnace find that General Electric's box furnace with water-jacketed cooling chamber is ideal for general-purpose work.

Says Lloyd G. Field, General Manager of Greenman Steel Treating Corp., Worcester, Mass.:

"As a heat-treating jobber, we have to produce high-quality work at lower cost than equipment manufacturers can do it themselves. We must be ready to handle all sorts of heat-treating jobs, yet our investment in equipment must be kept to a minimum. We find that our G-E box furnace satisfies all these requirements. It enables us to stay competitive because it produces superior work at low cost. It minimizes our equipment costs because its versatility is practically unlimited. We use it to copper braze, silver braze, anneal, and harden."

MANY SAVINGS, HIGH-QUALITY WORK

Mr. Field pointed out that operating costs are low because the insulating qualities of the furnace minimize heat loss. Automatic control of the heat assures him of high-quality work.

FOR APPLICATION HELP

Whether your operation demands a small-capacity, all-purpose furnace, or one that is engineered for a particular process and intended for high-production rates at the lowest possible cost, General Electric can satisfy your requirements. For application help from a G-E Heating Specialist, contact your G-E Apparatus Sales Office.

GENERAL ELECTRIC

WRITE NOW FOR THESE MODERN METAL PROCESSING BULLETINS

- Furnace and Induction Brazing, GEA-5889
- Annealing Malleable Iron, GEA-5797
- Forging with Induction Heat, GEA-5983
- Heat-treating Aluminum, GEA-5912

Address: General Electric Co., Section 720-129, Schenectady 5, N. Y.

AMS* helps customer save $24,000 a year!

9 Fixtures, Costing Under $2,000, Effect Huge Annual Saving!

When a manufacturer builds a good product . . . that's interesting; BUT, when a manufacturer builds a superior product that each year saves the buyer 12 TIMES what he pays for it . . . THAT'S NEWS! One of ALLIED METAL SPECIALTIES' customers, a leading aeronautical manufacturer, gave Allied the job of designing and fabricating 9 fixtures for their plant. Allied not only designed and built the fixtures, they engineered a $2,000 a month saving into the customer's line. How many fixtures, retorts, baskets, trays, racks, crates or muffles have you bought that will save you that kind of money?

Why not get the whole story from an Allied sales engineer? Just contact:

AMS* Allied

METAL SPECIALTIES, INC.

1505 Roland Heights Ave., Hampden Station, Baltimore 11, Md.

- Design and Fabrication
- All Metals and Alloys

Baskets - Crates - Trays
Racks - Fixtures
Muffles - Retorts

OVER ONE HUNDRED YEARS OF CONTINUOUS SERVICE ROUNDS, SQUARES, FLATS, HEXAGONS, OCTAGONS, BILLETS AND FORGINGS FOR PRODUCTION, TOOL ROOM AND MAINTENANCE REQUIREMENTS.

UP-TO-THE-MINUTE HY-TEN ALLOY STEELS

For over a century, Wheelock, Lovejoy & Company, Inc. has concentrated on the development of alloy and special steels with properties to meet individual needs. Today, WL has seven strategically located warehouses where you can get immediate delivery on any of the HY-TEN steels which have been developed by WL for unusual applications, plus many standard SAE and AISI grades. Every WL warehouse can supply these steels in rounds, squares, flats, hexagons, octagons, billets and forgings – every warehouse is staffed with expert metallurgists who are ready to assist you. Call on them.

Write today for your FREE COPIES of Wheelock, Lovejoy Data Sheets, indicating your title and company identification. It contains complete technical information on grades, applications, physical properties, tests, heat treating, etc.

WHEELOCK, LOVEJOY & COMPANY, INC.

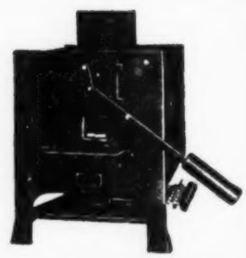
Warehouse Service

HY-TEN and AISI

In Canada

134 Sidney St., Cambridge 39, Mass.

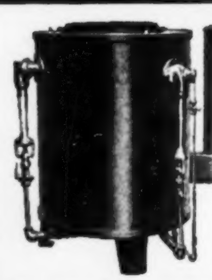
BUZZER HIGH SPEED Gas FURNACES



2400° F.
attained quickly with "BUZZER" High Speed Full Muffle Furnaces.

Designed primarily for high carbon and alloy steels.

NO BLOWER or POWER NECESSARY
. . . just connect to gas supply



"BUZZER" Atmospheric Pot Hardening Furnaces assure even heat up to 1650° F.

Used for Salt, Cyanide and Lead Hardening. Also adapted for Melting Aluminum.

Send for the complete "BUZZER" catalog today.

CHARLES A. HONES, INC.
123 South Grand Avenue, Baldwin, L. I., N. Y.

STATEMENT OF THE OWNERSHIP, MANAGEMENT, CIRCULATION, ETC.

Required by the Act of Congress of August 24, 1912, as amended by the Acts of March 3, 1933, and July 2, 1946 (Title 39, United States Code, Section 233) of **Metal Progress**, published monthly at Cleveland, Ohio, for October 1, 1954.

1. The names and addresses of the publisher, editor, managing editor, and business managers are: Publisher, American Society for Metals, 7301 Euclid Ave., Cleveland 3, Ohio; Editor, E. E. Thum, 7301 Euclid Ave., Cleveland 3, Ohio; Managing Editor, M. R. Hyslop, 7301 Euclid Ave., Cleveland 3, Ohio; Business Manager, W. H. Eisenman, 7301 Euclid Ave., Cleveland 3, Ohio.

2. The owner is: (if owned by a corporation, its name and address must be stated and also immediately thereunder the names and addresses of stockholders owning or holding 1 per cent or more of total amount of stock. If not owned by a corporation, the names and addresses of the individual owners must be given. If owned by a partnership or other unincorporated firm, its name and address, as well as that of each individual member, must be given). The American Society for Metals, 7301 Euclid Ave., Cleveland, which is an educational institution, the officers being: President, James B. Austin; Vice-President, G. A. Roberts; Secretary, W. H. Eisenman; Treasurer, W. A. Pennington; Trustees: R. L. Wilson, H. B. Knowlton, A. O. Schaefer, G. M. Young, Robt. Raudebauch. All officers as above, 7301 Euclid Ave., Cleveland 3, Ohio.

3. The known bondholders, mortgagees, and other security holders owning or holding 1 per cent or more of total amount of bonds, mortgages, or other securities are: None.

4. Paragraphs 2 and 3 include, in cases where the stockholder or security holder appears upon the books of the company as trustee or in any other fiduciary relation, the name of the person or corporation for whom such trustee is acting; also the statements in the two paragraphs show the affiant's full knowledge and belief as to the circumstances and conditions under which stockholders and security holders who do not appear upon the books of the company as trustees, hold stock and securities in a capacity other than that of a bona fide owner.

5. The average number of copies of each issue of this publication sold or distributed, through the mails or otherwise, to paid subscribers during the 12 months preceding the date shown above was: (This information is required from daily, weekly, semi-weekly, and tri-weekly newspapers only).

E. E. Thum,
Editor.

(Seal)

Sworn to and subscribed before me this 1st day of October, 1954.

Genevieve G. Fitzgerald.
Notary Public.

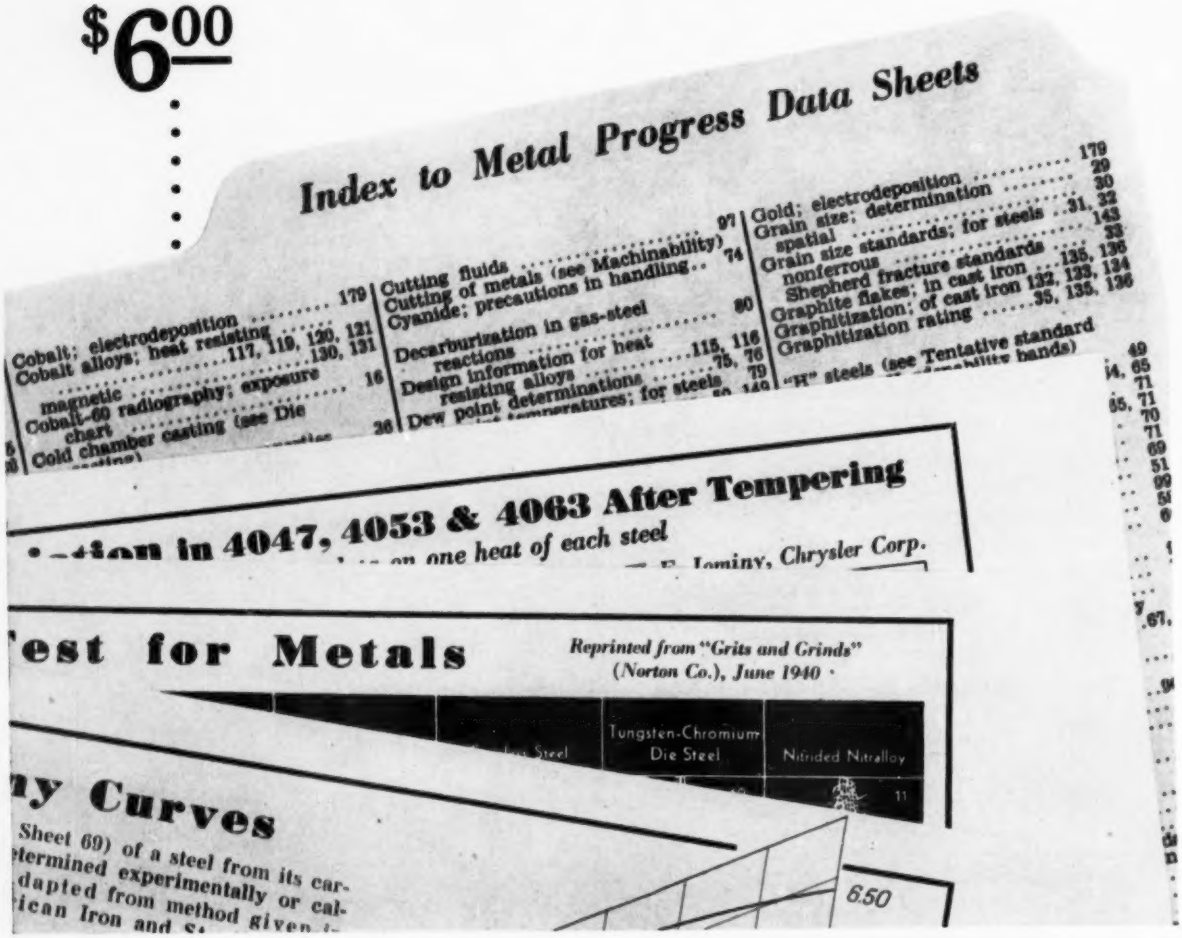
(My commission expires March 26, 1955.)

A Most Desirable Addition to your 1954 Supplement, METALS HANDBOOK

Metal Progress Data Sheets

192 Sheets 8½" x 11" loose in Envelope Binder
Subjects in all branches of Metallurgy

$6.00

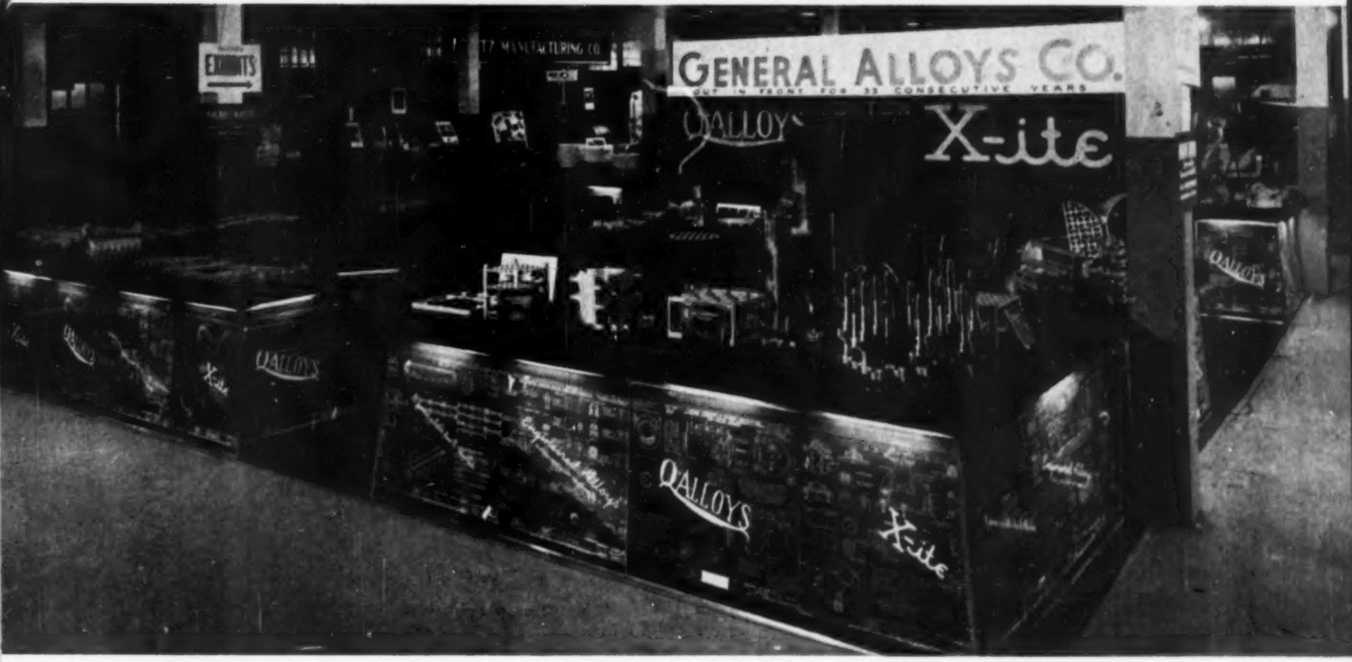


Order from **American Society for Metals**
7301 Euclid Avenue Cleveland 3, Ohio

THE FOOTSTEPS OF GENERAL ALLOYS MARK THE PATH OF AN INDUSTRY

36 YEARS AT A. S. M. SHOWS!

For thirty-six *consecutive* years General Alloys Company has exhibited Q-Alloy and X-ite Heat Resistant Alloy Tooling for all High Temperature Processes, and Corrosion Resistant, ENGINEERED Alloy Castings, DIRECTLY IN FRONT OF THE MAIN ENTRANCE, *the only continuous Alloy Exhibitor!*



"Tough Competition Demands the Best Engineered, Highest Quality Tools, So We're Back With General Alloys"---

Branch Offices and Representatives

BALTIMORE, Maryland
Emil Gathmann, Jr.
513 Park Avenue

BUFFALO, New York
Roy E. Lynd
812 Tacoma Ave.

BIRMINGHAM, Alabama
Ray F. Frings
Harry G. Mouat
1247 American Life Bldg.

CHICAGO, Illinois
General Alloys Company
Edward T. Connolly
224 S. Michigan Ave.

CLEVELAND 15, Ohio
E. E. Whiteside
2254 Euclid Ave.

DENVER, Colorado
Tracy C. Jarrett
95 S. Ammons St.

DETROIT 2, Michigan
General Alloys Company
Don B. Hutchins
3-147 General Motors Bldg.

FORT WAYNE 8, Indiana
The George O. Desautels Co.
P.O. Box 1176
R.R. 14, No. Bend Drive

HOUSTON 3, Texas
Wm. E. Brice Co.
1512 Pease Ave.

LOS ANGELES, California
Davis-Gregg Company
406 S. Main Street

LOUISVILLE 7, Kentucky
The George O. Desautels Co.
4003 Hycliffe Avenue

INDIANAPOLIS 8, Indiana
The George O. Desautels Co.
2302 N. Meridian Street
P.O. Box 7011

MUNCIE, Indiana
The George O. Desautels Co.
P.O. Box 776
405 Wysor Block

NEW ENGLAND
David L. Ellis
Woodland Road
West Concord, Mass.

NEW YORK 7, New York
General Alloys Co.
Alfred M. Sampter
50 Church Street

PHILADELPHIA, Pa.
John P. Clark Co.
124 S. Easton Road
Glenside, Pa.

PITTSBURGH 15, Pa.
Vincent C. Leatherby
400 So. Main St.
Sharpsburg 15, Pa.

ST. LOUIS 16, Missouri
Associated Steel Mills, Inc.
3163-65 Morganford Road

GENERAL ALLOYS CO., BOSTON, U. S. A.

writes a Customer, who, for the past two years had been cutting his first cost by price-buying vital heat-treat Tooling, and making "Package Deals" on alloy trays and fixtures with his furnace purchases. He further *insured* inferior casting quality by "economizing" on patterns, sometimes getting them "absorbed" on the casting order.

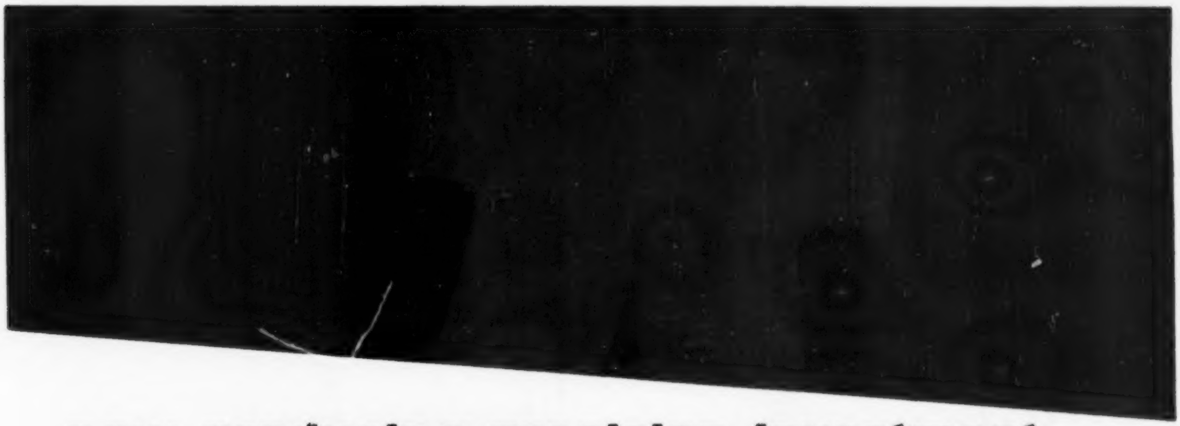
He, like many others got the FACTUAL EVALUATION of alloy *cost* in terms of *work* performed, & SERVICE LIFE PER $ COST, when he started keeping *accurate service records of alloy life, and tons of work handled per lb. of alloy.*

He also found that G. A. Casting Design-Process Technology ENGINEERED *to his production* and handling requirements, and his Furnace Conditions, from G.A.'s UNIQUE EXPERIENCE, and R&D. *increased production,* insured PREDICTABLE Service Life.

If You keep accurate RECORDS, We'll Guarantee to REDUCE YOUR ALLOY COSTS, *regardless* of the FIRST COST of your present alloy—GIVE US A CHANCE!

300 SL MERCEDES 165 MPH "BUSINESS COUPE"

Because we of G.A. believe: "That which is Truly Functional is Truly Beautiful", and know that this belief is shared by most American Engineers, even though such ideals are compromised to "fit a Market", we'd like you to see the utmost integration of *functional* design and fine craftsmanship on wheels. 240 HP. from 183 cu. in. engine. "Built to run continuously at 6200 rpm". Fuel Injection, 4 wheel independent springing, 0 to 60 in 5 secs., and braking to match. Wt. 2495 lbs. with 34 gals. of gas. If our order is filled in time, we'll burn some rubber and write it up the next M.P. In any event, we'll be showing our heels to the herd as usual. H.H.H.



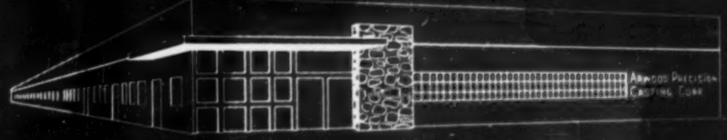
now producing precision investment castings for western industry

Arwood opens plant number 4

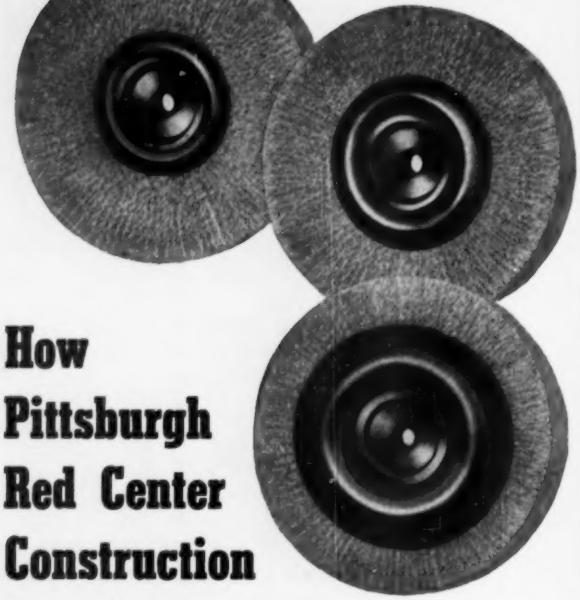
The growth of western industry and its exacting requirements have brought to California Arwood's fourth investment casting plant. Here you'll find the advanced tooling, metallurgical, and testing facilities necessary to serve you with the highest quality of precision investment castings. Small, intricate, investment-cast parts require no machining . . . quantities of these parts can be cast in unmachinable metals . . . and several parts can often be cast into a single assembly. Applications are virtually unlimited.

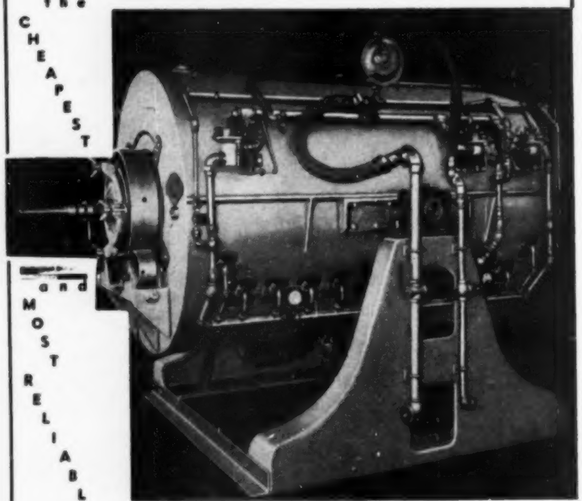
Arwood's engineers will be pleased to show you how you can save money and time. Won't you phone us or visit our plant? Technical consultation is free of obligation.

With the new California plant in full operation, Arwood's three eastern plants have been relieved of considerable overload. As a result, Arwood is able to extend more service to its customers throughout the nation.



Arwood PRECISION CASTING CORPORATION
70 Washington Street • Brooklyn 1, N. Y.
PLANTS: Groton, Conn. — Tilton, N. H. — Los Angeles, Calif.





Metal Progress

Taylor Lyman, *Publisher*

A. P. Ford, *Sales Manager*

George H. Loughner, *Production Manager*
7301 Euclid Ave., Cleveland 3—UTah 1-0200

ABC

District Managers
John F. Tyrrell and John B. Verrier, Jr.
55 W. 42nd St., New York 18—CHickering 4-2713
Ralph H. Cronwell
964 W. Villa Drive, Des Plaines, Ill.—VAnderbilt 4-1206
Don J. Billings
7301 Euclid Ave., Cleveland 3—UTah 1-0200

PUBLISHED BY AMERICAN SOCIETY FOR METALS, 7301 EUCLID AVE., CLEVELAND 3, OHIO—W. H. EISENMAN, SECRETARY

• Index to Advertisers •

KABLE PRINTING CO.